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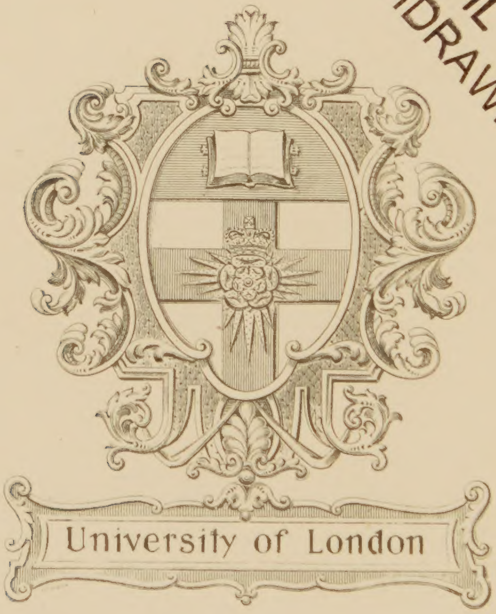

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Key Numbers of Elements

Ag	Al	As	Au	B	Ba	Be	Bi	Br	C	Ca	Cb	Cd	Ce	Cl	Co	Cr	Cs	Cu	Dy	Er	Eu	F	Fe	Ga	Gd	Ge	Gl	H	Hf	Hg	Ho	I	In	Ir	K	La	Li	Lu
32	55	13	33	54	79	75	15	5	16	77	51	29	59	4	44	46	85	31	67	69	64	3	43	25	65	20	75	2	73	30	68	6	26	36	83	58	81	72

Mg	Mn	Mo	N	Na	Nb	Nd	Ni	O	Os	P	Pb	Pd	Pr	Pt	Ra	Rb	Rh	Ru	S	Sa	Sb	Sc	Se	Si	Sn	Sr	Ta	Tb	Te	Th	Ti	Tl	Tm	U	V	W	Y	Yb	Zn	Zr
76	42	47	11	82	51	61	45	1	35	12	23	41	60	37	80	84	40	39	8	63	14	56	9	18	22	78	52	66	10	24	19	27	70	49	50	48	57	71	28	21

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INTERNATIONAL CRITICAL TABLES

ERRATA

(June, 1931)

Since the preparation of the errata sheets which were distributed with the volumes of International Critical Tables, the following additional errata should be noted:

VOLUME I

PAGE

80 Note below table. *For* see p. 78 *read* see p. 75.
128 No. 1325. *For* TiO *read* TiO_2.

PAGE

134 No. 1733. *For* U_2O_3 *read* UO_3 *and for* 6844.60 *read* 3986.6.

VOLUME II

PAGE

55 Thermal conductivity. *For* sec^{-1} (°C, cm^{-1}) *read* sec^{-1}/(°C, cm^{-1}).
130 Next to last line of text. *For* following table *read* Table 1.
151 Column 2, table head. *For* d_k/d_t *read* dk/dt.
152 Third column head of second table. *For* $\frac{\text{kg-cal per g}}{\text{A}}$ *read* kg-cal per g. The numerical values in the column are values of A.
157 Fig. 12. *For* dyne cm *read* dyne/cm.
161 Table heads. *For* Flash point *read* Flash point, °C.
379 Index Nos. 908 and 909. *For* 408 *read* 480.

PAGE

413 Insert (3.2) Charpy, 34, **126**: 1569; 98.
413 Pb-Bi-Sn. *For* (32) *read* (3.2).
416 Sn-Bi eutectic. *For* 58 *read* 56.
418 Pb-Sn-Bi diagram.
For (32) *read* (3.2).
For e_1 = 136° *read* 125°.
For e_2 = 124° *read* 135°.
For e_3 = 183° *read* 181°.
462 Footnote.* *For* αt *read* α_t.
462 Pt, 1000°. *For* (15) *read* (74).

VOLUME III

PAGE

4 pv equation for H_2 at −207.9°F. The pressure unit is m Hg. *For* p^5 *read* p^4.
6 pv equations for He at −258° to −183°C inclusive. The pressure unit is m Hg.
8 pv equation for Ne at −207.9°C. The pressure unit is m Hg. *For* p^4 *read* p^3.

PAGE

12–13 In all tables based on (62), pv = 1.0000 at 0°C. and 0 atm.
26 Table 3. Reference. *For* ;18 *read* ;03.
43 Al_2O_3. *Delete* (15).
436 (40). *For* ;93 *read* ;92.

VOLUME IV

PAGE

323 System $H_2O + NH_4NO_3 + CaSO_4$. The data for 25° are in g/l.

PAGE

324 System $H_2O + CaSO_4 + CaNO_3$. *For* % in both columns *read* % × 10^{-1}.

VOLUME V

PAGE

83 CO_2 Equation at head of table. *For* C_p *read* C_v.
133 $C_6H_{12}O$. *For* 17.55 *read* 175.5 and *for* 1.756 *read* 17.56.
163 Line 1. *For* 75.6*e* *read* 41.4*e*.

PAGE

Lines 5 to 8. *Change the values of c, d, g,* and *i to* −5.65, +5.27, +15.61 and +139.1, *resp.*
209 *Insert* (603.5) Lange and Durr, 7, **118**: 129; 25.
361 Fig. 1. *For* 2883 *read* 2083.

VOLUME VI

PAGE

19 Line 2 of Table 10 head matter. *For* $\mathbf{m}_0$ *read* $\mathbf{m}_0^2$.
230 Table 1, Col. 4. *For* 0.6531 *read* 0.06531; and *for* $.007742_2$ *read* $.0007742_2$.
259 Equation 1. *Insert* c in numerator.

PAGE

279 k for benzoic acid. *For* 10^{-4} *read* 10^{-5}. k for salicylic acid, *for* 10^{-4} *read* 10^{-2} and *for* 10^{-5} *read* 10^{-3}.
467 (64). *For* **12**: 566; 88 *read* **4**: appendix; 86 and *for* ;92 *read* ;93.

VOLUME VII

PAGE

351 (1104). *For 50 read 52.*

PAGE

486 (2197). *For* **41**: 161; 02 *read* **45**: 331; 03.

INDEX VOLUME

PAGE

1, 11, 21, 30. In second column of table add the items Woods and **Explosives.**

PAGE

9 Spectra, Band. *For* **4**: *read* **5**:.

INTERNATIONAL CRITICAL TABLES
OF
NUMERICAL DATA
PHYSICS, CHEMISTRY AND TECHNOLOGY

VOLUME VII

INTERNATIONAL CRITICAL TABLES OF NUMERICAL DATA, PHYSICS, CHEMISTRY AND TECHNOLOGY

Prepared under the Auspices of the International
Research Council and the National
Academy of Sciences

BY THE
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REFRACTIVITY OF ALL GASES AND VAPORS AND OF ELEMENTARY SUBSTANCES IN THE ISOTROPIC SOLID AND LIQUID STATES

J. J. Fox and F. G. H. Tate

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SYMBOLS

Symbols and formulae that occur in a single table are explained there.

d	Density.
F	Formula-weight in accordance with the printed formula.
g	As subscript, g indicates that the quantity pertains to the gas.
H	As subscript, H indicates that the quantity pertains to hydrogen, H_2.
M	Molecular weight.
n	Index of refraction referred to a vacuum.
p	Pressure.
λ	Wave-length.
λ_μ	Value of λ when the unit is $1\mu = 10^4$ Å; $\lambda_\mu = 10^{-4}\lambda_{\text{Å}}$.

SYMBOLE

Symbole und Formeln, die in einer einzelnen Tabelle vorkommen, sind dort erklärt.

d	Dichte.
F	Formelgewicht entsprechend der gedruckten Formel.
g	Als untergeschriebende Index bedeutet g, dass sich die Grösse auf ein Gas bezieht.
H	Als untergeschriebende Index bedeutet H, dass sich die Grösse auf Wasserstoff, H_2 bezieht.
M	Molekulargewicht.
n	Brechungsindex auf das Vakuum bezogen.
p	Druck.
λ	Wellenlänge.
λ_μ	Wert von λ, wenn als Einheit $1\mu = 10^4$ Å gilt; $\lambda_\mu = 10^{-4}\lambda_{\text{Å}}$.

SYMBOLES

Les symboles et formules qui se présentent dans une seule table sont expliqués à cette place.

d	Densité.
F	Formule-poids en accord avec la formule imprimée.
g	Comme souscrit, g indique que la quantité se rapporte à un gaz.
H	Comme souscrit, H indique que la quantité se rapporte à l'hydrogène, H_2.
M	Poids moléculaire.
n	Indice de réfraction par rapport au vide.
p	Pression.
λ	Longeur d'onde.
λ_μ	Valeur de λ lorsque l'unité est $1\mu = 10^4$ Å; $\lambda_\mu = 10^{-4}\lambda_{\text{Å}}$.

SIMBOLI

I simboli e le formule che si incontrano in ogni singola tabella sono ivi spiegate.

d	Densità.
F	Formula-peso corrispondente alla formula stampata.
g	Quando viene posto sotto, g indica che la quantità si riferisce allo stato gasoso.
H	Quando viene posto sotto, H indica che la quantità si riferisce all'idrogeno, H_2.
M	Peso molecolare.
n	Indice di rifrazione riferito al vuoto.
p	Pressione.
λ	Lunghezza d'onda.
λ_μ	Valore di λ quando l'unità è $1\mu = 10^4$ Å; $\lambda_\mu = 10^{-4}\lambda_{\text{Å}}$.

The indices for solids and liquids are given for the actual temperatures at which they were determined; those for gases and vapors have in most cases been reduced to 0°C and 760 mm of Hg by some one of several, not always concordant, formulae. As values obtained previous to 1898 have been collected by Dufet (23), such values are, in general, omitted from this section if more recent data of equal or superior accuracy are available; a discussion of them will usually be found in the recent papers.

The variation of the refractivity with temperature and pressure has been given special consideration in the case of air; for other gases and vapors the available data are included with the refractivities in Table 4, if there is an indication that the ideal gas laws do not apply.

REFRACTIVITY OF AIR

Except as the contrary is stated, the following data refer to dry air containing the normal amount (0.03%) of CO_2. Doubling this amount of CO_2 will increase n by less than 1 in 10^7 (54).

TABLE 1.—REFRACTIVITY OF DRY AIR

For dispersion formulae, *see* Table 2; unit of λ = 1 Å; of p = 1 mm of Hg; temperature = t,°C

(A) Range: λ = 2218 to 8999, p = 760 mm (54). Observations were made at constant t, and gave directly the values of n for pressures near 760; these were reduced to p = 760 on the assumption that over this short range $(n - 1)/p$ is independent of p. For smoothed values, *see* Table 3.

t	0°C	15°C	30°C
λ	$(n - 1)10^6$		
2218Cu			298.27
2246Cu			296.04
2303Cu			290.75
2369Cu			287.90
2392Cu	322.34	305 00	286.71
2406Cu	322.27		286.94
2441Cu	320.90	304.66	286.23
2492Cu	319.66	301.22	285.77
2618Cu	314.58	296.24	283.36
2739Fe	310.17	293.20	280.40
2766Cu	313.94	295.05	278.71
2824Cu	310.38	294.08	277.93
2851Fe	308.58		276.83
2882Cu	308.06	292.10	277.41
2918Fe	307.98	291.23	275.21
2961Cu	307.83	291.40	274.62
2987Fe	307.37	291.80	274.48
2997Cu	307.42	291.53	274.26
3010Cu	307.82	289.48	275.19
3036Cu	308.41	290.82	274.50
3055Fe		291.05	
3063Cu	306.61	290.12	275.07
3075Fe			274.73
3116Fe	304.89	288.98	274.64
3175Fe	303.43	289.40	272.02
3205Fe	303.82	288.49	272.71
3280Fe	302.89	287.25	273.25
3347Fe	302.27	285.70	272.08

REFRACTIVITY: DRY AIR.—(*Continued*)

t	0°C	15°C	30°C
λ	$(n - 1)10^6$		
3413Fe	302.36	285.97	271.56
3485Fe	300.45	285.70	
3513Fe	301.00	285.80	271.60
3594Fe	298.89	284.50	271.49
3640Fe	298.61	284.24	270.00
3659Fe	299.87	283.63	269.96
3701Fe	299.64	283.42	267.90
3753Fe	298.80	283.18	268.80
3787Fe		283.16	
3790Fe		282.91	
3843Fe	297.75	282.92	268.95
3846Fe			268.22
3865Fe		282.61	
3867Fe	298.14		
3906Fe	299.33	282.16	267.61
3935Fe	297.98	281.48	268.91
3969Fe		281.98	
3977Fe	296.62	281.59	268.14
3983Fe	297.37	282.14	267.73
4005Fe		281.75	
4021Fe	297.17	281.57	266.99
4076Fe	297.04	281.64	268.87
4095Fe	296.66	280.95	267.60
4118Fe	297.34	280.93	
4147Fe		280.78	266.68
4191Fe		280.77	
4210Fe	297.00	280.81	266.87
4213Fe	296.36	280.53	266.97
4233Fe		280.71	
4245Fe	296.59	280.47	266.80
4282Fe	295.61	280.76	265.07
4315Fe	296.08	280.04	266.38
4352Fe	296.75	280.59	266.28
4369Fe	295.42	279.61	266.39
4375Fe		279.83	
4422Fe	295.47	279.28	266.44
4427Fe		279.67	
4484Fe	295.09		
4494Fe		279.64	265.62
4531Fe		279.44	
4547Fe	294.73	278.90	265.50
4592Fe	294.34	279.19	265.49
4602Fe		279.07	
4647Fe	294.63	278.78	265.49
4691Fe	294.30	278.52	264.97
4736Fe	293.89	278.92	265.36
4789Fe	293.57	277.84	264.74
4859Fe	293.80	278.76	264.65
4903Fe	293.76	278.32	264.71
4966Fe	293.32	278.91	264.60
5001Fe	293.55		264.20
5012Fe		278.30	
5051Fe	293.59	276.40	264.20
5110Fe	293.05	278.43	264.33
5167Fe	292.68	277.93	263.90
5171Fe	293.09	277.69	263.73
5232Fe	293.42	277.92	263.64
5266Fe	293.87		263.65
5324Fe	293.61	277.59	263.08
5397Fe	293.01	277.19	263.61
5455Fe	292.44	277.34	263.43
5506Fe	292.26	277.28	263.60
5569Fe	292.59	277.90	263.13
5624Fe	293.13	277.61	263.26
5658Fe	292.37	277.07	263.00
5709Fe	293.16	277.13	262.82
5763Fe	292.51	276.75	262.41
5852Ne		276.92	262.96
5881Ne		276.81	262.99
5883Fe	292.46	276.75	
5934Fe		276.71	263.88
5944Ne		276.36	262.99
6003Fe	292.85	276.58	
6029Fe			263.41
6065Fe	291.89	276.70	262.40
6074Ne		276.42	262.61
6096Ne		276.36	262.61
6136Fe	291.52	276.60	262.34
6143Ne		276.49	262.59
6163Ne		276.21	262.66
6191Fe	291.33	276.70	262.07
6217Ne		276.15	262.57
6219Fe		276.29	
6230Fe		276.79	
6246Fe		276.73	
6252Fe	291.26	276.07	262.07
6266Ne		276.49	262.48
6297Fe	290.40	274.65	
6304Ne		275.77	262.38
6318Fe		276.74	
6334Ne		276.16	262.47
6335Fe	291.06	275.81	262.10
6382Ne		276.36	262.40
6393Fe	291.11	276.37	262.03
6400Fe		276.51	
6402Ne		276.32	262.39
6430Fe	291.04	276.14	261.53
6462Fe	290.55	276.90	262.18
6494Fe	290.70	276.18	261.80
6506Ne		276.22	262.15
6532Ne		276.10	262.27
6546Fe	290.90	276.10	261.98
6563H		276.02	
6598Ne		276.02	261.96
6609Fe	291.69	276.28	261.25
6663Fe	291.36	275.96	262.74
6678Ne		275.46	
6678Fe	290.75	276.02	261.82
6717Ne		276.02	261.81
6750Fe	290.19	276.24	262.68
6752A		275.60	
6841Fe	290.70		
6843Fe			260.94
6871A		275.09	
6916Fe			263.33
6929Ne		275.76	261.84
6937A		275.45	
6945Fe	289.97	274.93	262.13
6965A		274.87	
6978Fe	290.39	275.08	261.45
7016Fe		276.54	
7023Fe	290.91		
7030A		274.90	
7032Ne		275.71	261.74

Refractivity: Dry Air.—*(Continued)*

t	0°C	15°C	30°C
λ	$(n-1)10^6$		
7038Fe			261.01
7059Ne		273.70	
7067A		274.87	
7068Fe	290.24	276.71	262.41
7090Fe	290.53		
7130Fe	289.87	275.76	260.90
7147A		274.99	
7164Fe	289.50	276.12	261.36
7173Ne		275.67	
7187Fe		274.93	262.64
7207Fe		275.29	
7223Fe	290.57		260.89
7245Ne		275.26	261.66
7272A		274.88	
7293Fe	291.45		262.24
7372A		275.12	
7383A		274.66	
7389Fe	289.77		261.18
7411Fe	290.06	275.19	262.02
7438Ne		274.24	
7445Fe	290.36	275.62	260.94
7495Fe	290.68	276.45	261.27
7503A		274.83	
7511Fe		274.97	
7514A		274.89	
7531Fe	289.72	274.07	261.66
7568Fe			260.68
7586Fe	290.30		261.66
7620Fe		274.81	259.47
7635A		274.61	
7664Fe	289.58	274.81	261.12
7710Fe			261.12
7724A		274.49	
7748Fe	289.02	274.17	260.31
7780Fe	289.74	274.73	260.29
7832Fe	290.23	275.06	261.12
7937Fe	288.78	274.55	261.54
7945Fe	290.49	274.71	261.27
7948A		274.54	
7998Fe	288.67	274.87	260.66
8006A		274.58	
8014A		274.36	
8046Fe	289.03	275.01	260.56
8085Fe	290.26	273.92	261.00
8103A		274.28	
8115A		274.20	
8220Fe	289.52	273.61	261.22
8264A		274.25	
8327Fe	289.43	273.88	260.66
8387Fe	289.04	274.12	259.93
8408A		274.36	
8424A		274.27	
8468Fe	290.01		260.66
8514Fe		274.59	260.42
8521A		274.63	
8611Fe			259.90
8661Fe	288.10	274.07	260.10
8674Fe			261.26
8688Fe	288.73	273.41	260.48
8824Fe		273.55	260.54
8999Fe		273.56	259.15

(*B*) Values by various observers. Range: λ = 2 652 to 130 000. For older values, *see* (23, 54, 58). Data reduced by the formula

$$r_0 = r \cdot \frac{760}{p} \cdot \frac{1+\alpha t}{1+\gamma p};\ r = (n-1)10^6$$

λ	r_0	λ	r_0	λ	r_0
$\gamma = 0$, $\alpha = 1/273$ (29)		$\gamma = 7(10)^{-7}$, $\alpha = 0.003670$ (35)		(81)	
2 652	314.00	5 894	292.98	5 461	291.41
2 894	309.02	67 094	288.06	(25)	
2 967	307.37	86 784	288.75	4 359	295.2
3 022	306.62			5 461	292.9
3 188	304.30				
3 965	298.00	$\gamma = 7(10)^{-7}$, $\alpha = 0.003670$ (75)*			
4 471	295.55				
4 713	294.40	10 000	290	(84)	
5 016	293.50	20 000	289	8 000	290.9
5 876	291.96	30 000	289	10 000	289.7
6 678	291.20	40 000	289	20 000	288.2
$\gamma = 0$, $\alpha = 1/273$ (14)				30 000	288.5
				40 000	288.0
4 861	295.11			50 000	287.9
5 461	293.60			63 000	287.3
5 790	292.98	(62)		80 000	287.8
6 563	291.92	5 461	293.42	130 000	286.9

* Based on preceding value for λ = 5894, Koch (35)

Variation of Refractivity of Air with Temperature, Pressure and Humidity

Temperature.—$(n-1)_0 = (n-1)_t \cdot (1+\alpha t)$. Meggers and Peters (54) find $\alpha = 0.00367 + \frac{0.000003}{\lambda_\mu^2}$; Koch (35) and Statescu (75) used $\alpha = 0.003670$; Pèrard (59) used $\alpha = 0.003716$; Cuthbertson (14), Howell (29), and most of the other workers have used $\alpha = 0.003663 = 1/273$. At $t = -189$ to -188°C, Ayres (3) obtained the following values, agreeing with those of Scheel (68):

λ		507	735	914 mm of Hg
5461 Å	$(n-1)10^6 =$	654.3	954.1	1189.9
5780 Å	$(n-1)10^6 =$	653.3	951.1	1186.4

Pressure.—For small ranges in p, t constant, $(n-1)/p$ may be regarded as a constant. Opinions differ regarding the effect of relatively great changes. Mathews (53) concludes that $(n-1)/p$ is constant over the range $p = 26$ to $p = 760$ mm, but many consider that Mascart's relation, $(n-1)/p = K(1+\gamma p)$, fits the observations better; the following values have been used for γ, the unit of p being 1 mm of Hg:

λ	5 461	5 461	5 462
p	0 to 760	0 to 760	760 to 7 600
$10^8\gamma$	357 ± 39	667 ± 87	51 ± 5
Lit.	(62)	(81)	(58)
λ	4 359	4 000 to 6 500	5 000 to 86 000
p	760 to 7 600	near 760	0 to 760
$10^8\gamma$	53 ± 5	240	70
Lit.	(58)	(59)	(35)

For the range λ = 4050 to 5090 Å, p = 30 to 100 atm., t = 9 to 14°C, it has been found (70, 71, 73) that, whatever the pressure,

$$\frac{(n-1)_\lambda}{(n-1)_{5461}} = 0.98086\left\{1 + \frac{0.0056376}{\lambda_\mu^2} + \frac{54.01(10)^{-6}}{\lambda_\mu^4}\right\}$$

For variation with p at $t = -188$°C, *see* preceding text.

Humidity.—If n_d and n_m = index for dry air and for air in which the partial pressure of water vapor is m mm of Hg, then Lorenz (43) concludes that $n_d = n_m + \frac{41m(10)^{-6}}{760}$.

TABLE 2.—DISPERSION FORMULAE FOR DRY AIR

$\lambda_\mu = 10^{-4}\lambda_A$, unit of $\lambda_A = 1$ Å

For the formula $(n - 1)10^6 = \beta/(\mu - \lambda_\mu^{-2})$, Cuthbertson (14) finds $\beta = 51\,626$, $\mu = 179.17$; for the Cauchy formula $(n - 1)\ 10^6 = A + B\lambda_\mu^{-2} + C\lambda_\mu^{-4}$, the following values have been found, those of (54) being the best. Temperature is t, °C; pressure = 760 mm of Hg, except as noted.

t, °C	A	B	C	$1000B/A$	$10^6C/A$	Lit.
0	287.566	1.3412	0.03777	4.664_1	131.3_5	(54)
15	272.643	1.2288	0.03555	4.507_0	130.3_9	(54)
30	258.972	1.2259	0.02576	4.733_7	99.4_7	(54)
0	287.987*	1.804*	0	6.26_4*	0	(65)
0	288.02	1.482	0.0309	5.14_5	$107._3$	(59)
11				5.63_8†	54.01†	(70, 71, 73)

* Freed of CO_2.

† For pressures between 30 and 100 atm., t = 12°C, 4050 Å $< \lambda <$ 5090 Å.

TABLE 3.—CORRECTIONS FOR CONVERTING WAVE-LENGTHS AND THEIR RECIPROCALS IN AIR AT 15°C AND 760 MM OF HG TO THEIR VALUES IN A VACUUM (54)

If λ_a, λ_v = values in air and in vacuum, respectively, then $\lambda_v = \lambda_a + \delta_\lambda$ and $1/\lambda_a = 1/\lambda_v + \delta_\nu$, where δ_λ and δ_ν have the values given in the table. The values of $(n - 1)$ are those computed by means of the equation $(n - 1)10^6 = 272.643 + 1.2288\lambda_\mu^{-2} + 0.03555\lambda_\mu^{-4}$ which was derived from the observations in Table 1, section A. Unit of λ and δ_λ = 1 Å; of δ_ν = 1 cm⁻¹ = 10⁸ Å⁻¹.

λ	$(n - 1)10^6$	δ_λ	δ_ν
2 000	325.582	0.6512	16.274
2 050	322.012	0.6601	15.703
2 100	318.786	0.6695	15.175
2 150	315.863	0.6791	14.687
2 200	313.207	0.6891	14.232
2 250	310.787	0.6993	13.808
2 300	308.575	0.7097	13.412
2 350	306.550	0.7204	13.041
2 400	304.691	0.7313	12.692
2 450	302.981	0.7423	12.363
2 500	301.405	0.7535	12.053
2 550	299.948	0.7649	11.759
2 600	298.600	0.7764	11.481
2 650	297.350	0.7880	11.217
2 700	296.188	0.7997	10.967
2 750	295.108	0.8115	10.728
2 800	294.100	0.8235	10.500
2 850	293.160	0.8355	10.283
2 900	292.280	0.8476	10.076
2 950	291.457	0.8598	9.877
3 000	290.685	0.8721	9.687
3 050	289.960	0.8844	9.504
3 100	289.279	0.8968	9.329
3 150	288.638	0.9092	9.160
3 200	288.033	0.9217	8.998
3 250	287.463	0.9343	8.842
3 300	286.924	0.9469	8.692
3 350	286.415	0.9595	8.547
3 400	285.933	0.9722	8.407
3 450	285.476	0.9849	8.272
3 500	285.043	0.9977	8.142
3 550	284.632	1.0104	8.016
3 600	284.241	1.0233	7.893
3 650	283.869	1.0361	7.774
3 700	283.516	1.0490	7.660
3 750	283.179	1.0619	7.550
3 800	282.858	1.0749	7.442
3 850	282.551	1.0878	7.337
3 900	282.259	1.1008	7.235
3 950	281.979	1.1138	7.137
4 000	281.712	1.1268	7.041
4 050	281.456	1.1399	6.948
4 100	281.211	1.1530	6.857
4 150	280.976	1.1661	6.769
4 200	280.751	1.1792	6.683
4 250	280.536	1.1923	6.599
4 300	280.329	1.2054	6.517
4 350	280.130	1.2186	6.437
4 400	279.939	1.2317	6.360
4 450	279.755	1.2449	6.285
4 500	279.578	1.2581	6.211
4 550	279.408	1.2713	6.139
4 600	279.244	1.2845	6.069
4 650	279.086	1.2978	6.000
4 700	278.934	1.3110	5.933
4 750	278.788	1.3242	5.868
4 800	278.646	1.3375	5.804
4 850	278.509	1.3508	5.741
4 900	278.378	1.3640	5.680
4 950	278.250	1.3773	5.620
5 000	278.127	1.3906	5.561
5 050	278.008	1.4039	5.503
5 100	277.893	1.4173	5.447
5 150	277.781	1.4306	5.392
5 200	277.674	1.4439	5.336
5 250	277.569	1.4572	5.285
5 300	277.468	1.4706	5.234
5 350	277.370	1.4839	5.183
5 400	277.275	1.4973	5.133
5 450	277.183	1.5106	5.084
5 500	277.094	1.5240	5.037
5 550	277.007	1.5374	4.990
5 600	276.923	1.5508	4.944
5 650	276.841	1.5642	4.899
5 700	276.762	1.5775	4.854
5 750	276.685	1.5909	4.811
5 800	276.610	1.6043	4.768
5 850	276.537	1.6177	4.726
5 900	276.466	1.6311	4.685
5 950	276.398	1.6446	4.644
6 000	276.331	1.6580	4.604
6 050	276.265	1.6714	4.565
6 100	276.202	1.6848	4.527
6 150	276.140	1.6983	4.489
6 200	276.080	1.7117	4.452
6 250	276.022	1.7251	4.415
6 300	275.965	1.7386	4.379
6 350	275.909	1.7520	4.344
6 400	275.855	1.7655	4.309
6 450	275.802	1.7789	4.275
6 500	275.751	1.7924	4.241
6 550	275.700	1.8058	4.208
6 600	275.651	1.8193	4.175
6 650	275.604	1.8328	4.143
6 700	275.557	1.8462	4.112
6 750	275.511	1.8597	4.081
6 800	275.467	1.8732	4.050
6 850	275.423	1.8866	4.020
6 900	275.381	1.9001	3.990

TABLE 3.—(*Continued*)

λ	$(n-1)10^6$	δ_λ	δ_ν
6 950	275.339	1.9136	3.961
7 000	275.299	1.9271	3.932
7 050	275.259	1.9406	3.903
7 100	275.221	1.9541	3.875
7 150	275.183	1.9676	3.847
7 200	275.146	1.9811	3.820
7 250	275.110	1.9945	3.793
7 300	275.074	2.0080	3.767
7 350	275.039	2.0215	3.741
7 400	275.006	2.0350	3.715
7 450	274.972	2.0485	3.690
7 500	274.940	2.0620	3.665
7 550	274.908	2.0756	3.640
7 600	274.877	2.0891	3.616
7 650	274.846	2.1026	3.592
7 700	274.817	2.1161	3.568
7 750	274.788	2.1296	3.545
7 800	274.759	2.1431	3.522
7 850	274.731	2.1566	3.499
7 900	274.703	2.1702	3.476
7 950	274.676	2.1837	3.454
8 000	274.650	2.1972	3.432
8 050	274.624	2.2107	3.410
8 100	274.599	2.2243	3.389
8 150	274.574	2.2378	3.368
8 200	274.549	2.2513	3.347
8 250	274.525	2.2648	3.326
8 300	274.502	2.2784	3.306
8 350	274.478	2.2919	3.286
8 400	274.456	2.3054	3.266
8 450	274.434	2.3190	3.246
8 500	274.412	2.3325	3.227
8 550	274.390	2.3460	3.208
8 600	274.369	2.3596	3.189
8 650	274.349	2.3731	3.170
8 700	274.328	2.3867	3.152
8 750	274.309	2.4002	3.134
8 800	274.289	2.4137	3.116
8 850	274.270	2.4273	3.099
8 900	274.251	2.4408	3.080
8 950	274.232	2.4544	3.063
9 000	274.214	2.4679	3.046
9 050	274.196	2.4815	3.029
9 100	274.179	2.4950	3.012
9 150	274.161	2.5086	2.995
9 200	274.144	2.5221	2.979
9 250	274.128	2.5357	2.963
9 300	274.111	2.5492	2.947
9 350	274.095	2.5628	2.931
9 400	274.079	2.5763	2.915
9 450	274.064	2.5899	2.899
9 500	274.048	2.6035	2.884
9 550	274.033	2.6170	2.869
9 600	274.018	2.6306	2.854
9 650	274.004	2.6441	2.839
9 700	273.989	2.6577	2.824
9 750	273.975	2.6713	2.809
9 800	273.961	2.6848	2.795
9 850	273.947	2.6984	2.780
9 900	273.934	2.7119	2.766
9 950	273.920	2.7255	2.752
10 000	273.907	2.7391	2.738

TABLE 4.—REFRACTIVITY OF GASES AND VAPORS

For dispersion formulae, *see* Table 5

Order: Elementary substances, pure compounds, mixtures The formula used for reducing the observations is indicated, i known, by *I*, *II*, or *III*: *I*, $r_0 = r \cdot \frac{760(1+\alpha t)}{p(1+\gamma p)}$, unless othe values are given, $\gamma = 0$ and $\alpha = 1/273$; *II*, $r_0 = rd_0/d$; *III*, $r_0 =$ $r[(F/d)_g]_{t,p} \times [(d/M)_H]_{0,760}$; $r = (n-1)10^6$. If the gas is idea and diatomic, and if $\gamma = 0$ and $\alpha = 1/273 (= 0.003663)$, all thre formulae give the same value, and $r_0 = 10^6(n-1)_{0,760}$. $K =$ r_0/p. Unit of λ = 1 Å; of p = 1 mm of Hg; temperature = t,°C

I. A-Table.—Elementary Substances

A, Argon; *cf.* (82)*

λ	r_0
I (65)	
2 441.6	303.78
2 492.1	302.80
2 618.4	300.38
2 766.4	298.11
2 824.4	297.14
2 961.2	295.50
3 349.3	291.62
4 275.1	286.34
4 651.1	284.99
5 105.6	283.79
5 153.2	283.67
5 218.2	283.50
5 700.2	282.55
5 782.2	282.47
III (16); *cf.* (12)	
4 800	283.8
5 086	283.1
5 209	282.8
5 461	282.3
5 769	281.7
5 790	281.7
6 438	280.9
(7)	
4 861	286.0
5 016	285.6
5 461	284.6
5 876	283.8
5 896	283.7
6 563	282.9
(1)†	
4 359	285.1
5 461	281.6
5 770	280.2
5 790	280.2
6 439	279.6

* At 0°C and 760 mm Hg, (82) finds $r_0 = 282.70$ for λ = 5462.3.

† Less accurate than those of (16).

As₂, Arsenic

λ	r_0
III (20)	
5 461	1 579
5 893	1 552

Br₂, Bromine

λ	r_0
III (18)	
5 461	1 184.9
5 600	1 179.6
5 700	1 176.2
5 750	1 174.1
5 800	1 173.5
6 000	1 166.2

Br₂.—(*Continued*)

λ	r_0
6 438	1 157.0
6 708	1 152.5

Cd₂, Cadmium

λ	r_0
III (20)	
5 183	2 780
5 461	2 725
5 893	2 675
6 562	2 675

Cl₂, Chlorine

λ	r_0
III (18)	
4 799.9	791.66
5 085.8	787.91
5 209.1	786.51
5 460.7	784.00
5 769.5	781.35
5 790.5	781.21
6 438.5	777.03
6 707.85	775.63

F₂, Fluorine

λ	r_0
III (21)	
5 893	195 *ca.*

H₂, Hydrogen*

λ	r_0
I (14)	
4 861	140.64
5 461	139.71
5 780	139.33
6 563	138.66
I (35, 36); *cf.* (34)	
2 303	159.435
2 379	157.693
2 448	156.300
2 465	155.978
2 536	154.694
2 577	154.017
2 676	152.538
2 754	151.510
2 761	151.423
2 858	150.268
2 894	149.873
2 926	149.530
2 968	149.118
3 127	147.717
3 133	147.661
3 342	146.130
3 545	144.950
3 664	144.321
3 705	144.103
3 908	143.246
3 985	142.979

H_2.—(*Continued*)

λ	r_0
4 048	142.749
4 079	142.642
4 109	142.550
4 360	141.785
4 917	140.527
5 462	139.660
5 895	139.24
6 710	138.53
67 094	136.10
86 784	136.06

(43)

λ	r_0
5 896	138.7
6 708	138.0

I (48)

$\gamma = 0,\ \alpha = 0.00381$

λ	r_0
5 085	139.2
5 896	138.7
6 438	138.3

(60)

λ	r_0
4 677	140.8
4 800	140.6
5 085	140.0
5 378	139.3
5 896	139.0
6 438	138.5

I (68)

λ	r_0
4 358	140.6
4 712	139.8
4 922	139.6
5 780	138.9
6 676	137.6

I (29)

λ	r_0
2 753	151.87
2 894	150.61
3 022	149.73
3 341	147.37
4 026	144.40
4 471	142.80
4 713	142.38
4 916	142.03
5 876	141.05

I (33)

λ	r_0
1 854.6	175.996
1 862.7	175.541
1 935.8	171.824
1 990.5	169.395
2 303	159.418
2 379	157.681
2 536	154.690
2 754	151.500
2 894	149.859
2 968	149.101
3 342	146.133
4 048	142.741
4 079	142.632
4 360	141.773
5 461	139.650†

---

* For the range $56 < p < 2760$ mm of Hg and t = constant, $(n - 1)10^6 = kp$, even at very low temperatures; for $\lambda = 5461$, $k = 0.615$ if $t = -187.5°C$, and $k = 0.687$ if $t = -191.1°C$; for $\lambda = 5780$, $t = -191.1°C$, $k = 0.683$ per mm of Hg (3).

† Same value found by Schacherl (67).

He, Helium; *cf.* (82)

III (16)

λ	r_0
4 800	35.04
5 086	34.99
5 209	34.98
5 461	34.95
5 769	34.82
5 791	34.92
6 438	34.86

I (37)

λ	r_0
2 303	36.258
2 379	36.146
2 448	36.063
2 465	36.046
2 536	35.959
2 577	35.916
2 676	35.827
2 754	35.760
2 761	35.749
2 858	35.672
2 894	35.646
2 926	35.624
2 968	35.605
3 342	35.396
3 545	35.133
3 861	35.197
3 985	35.173
4 109	35.139
4 917	34.989
5 462	34.925

I (7)

λ	r_0
4 861	35.10
5 016	35.08
5 461	35.04
5 876	35.00
5 896	35.00
6 563	34.95

Hg_2, Mercury

III (20)

λ	r_0
5 183	1 885
5 461	1 882
5 893	1 866
6 562	1 799

I_2, Iodine*

III (18)

λ	r_0
5 000	$2\ 12_0$
5 005	$2\ 16_0$
5 100	$2\ 21_0$
5 250	$2\ 25_0$
5 600	$2\ 17_0$
6 180	$2\ 13_0$
6 215	$2\ 13_0$
6 438	$2\ 10_0$
6 708	$1\ 97_0$

* Not very accurate.

K, Potassium*

* For dispersion near absorption bands, *see* Bevan (5).

Kr, Krypton

III (16)

λ	r_0
4 799.9	431.80
5 085.8	430.34
5 029.1	429.78
5 460.7	428.74
5 769.5	427.64
5 790.5	427.61
6 438.5	425.80
6 707.8	425.33

N_2, Nitrogen;* *cf.* (83)

I (14)

λ	r_0
4 861	301.21
5 461	299.77
6 563	298.16

I (37)

$\alpha = 0.003675$

λ	r_0
2 379	326.09
2 448	324.11
2 465	323.64
2 536	321.80
2 577	320.84
2 676	318.71
2 754	317.21
2 760	317.08
2 858	315.42
2 894	314.84
2 926	314.34
2 968	313.74
3 342	309.37
3 545	307.64
3 705	306.36
3 908	305.11
3 985	304.73
4 079	304.24
4 109	304.06
4 917	301.06
5 461	299.77

I (68)

$\alpha = 0.003675$

λ	r_0
4 358	302.0
4 712	301.4
4 922	299.9
5 461	298.2
5 780	297.6
6 576	296.1
7 056	294.5

I (66)

λ	r_0
3 342	307.0
3 650	303.4
4 046	301.0
4 358	299.5
5 461	296.7
5 769	296.6

(3)

$t = -189.2°C;\ \lambda = 5461$ Å

$\Delta‡ = 0.03_6 p$

p†	$(n - 1)10^6$
10.1 cm	133.3
21.9	288.2
35.5	461.8
42.8	558.9
76.2	1 004.0
76.4	1 009.9
76.6	1 008.6
100.9	1 347.0
101.0	1 349.3
122.8	1 662.5
122.8	1 659.0
143.4	1 961.1
143.5	1 962.9
149.5	2 049.7

N_2.—(*Continued*)

$t = -190.6°C;\ \lambda = 5461$ Å

$\Delta‡ = 0.03_5 p$

p†	$(n - 1)10^6$
10.8 cm	144.1
22.2	294.4
35.6	470.6
39.0	515.3
72.6	975.4
76.3	1 023.3
110.4	1 508.3
123.3	1 692.4
132.3	1 829.9

$t = -191.6°C;\ \lambda = 5461$ Å

$\Delta‡ = 0.2_3 p$

p†	$(n - 1)10^6$
11.0 cm	149.8
20.2	278.5
33.9	456.6
75.8	1 034.3
119.6	1 669.5

* At 21°C, λ = 5461 Å, and d between $70d_0$ and $200d_0$, d_0 = density at 0°C and 760 mm, $\frac{n^2 - 1}{n^2 + 2} \cdot \frac{d_0}{d}$ (= 199.7×10^{-6}) is more nearly constant than either $(n^2 - 1)/d$ or $(n - 1)/d$ (57).

† If computed by van der Waals's equation with $a = 126\ 070$, $b = 1.325$, then both $(n - 1)/d$ and $(n^2 - 1)/(n^2 + 2)d$ are constant within 2 %.

‡ $\Delta \equiv (n_{5461} - n_{5780}) \times 10^6$, where 5780 is the mean λ of the yellow lines of Hg; p is expressed in cm of Hg. At −191.6°C the coefficient of p is nearly 7 times as great at −190.6°C.

Na, Sodium*

* For dispersion near absorption bands, *see* Bevan (5).

Ne, Neon

III (16)

λ	r_0
4 799.9	67.31
5 085.8	67.23
5 209.1	67.21
5 460.7	67.16
5 769.5	67.10
5 790.5	67.10
6 438.5	67.02

O_2, Oxygen*

I (14)

λ	r_0
4 861	273.45
5 461	271.70
5 790	270.99
6 563	269.75

I (29)

λ	r_0
2 753	324.23
2 894	293.60
3 022	291.19
3 188	287.93
3 889	279.65
4 471	276.31
4 713	275.11
5 016	274.01
5 876	271.84
6 678	270.83

O_2.—(*Continued*)

λ	r_0
(1)	
4 359	274.7
5 461	270.6
5 780	270.1
6 439	269.2
I (66)	
3 342	283.2
4 047	277.6
4 359	275.2
5 461	272.5
5 771	271.9
I (35); *cf.* (34)	
$\gamma = 11(10)^{-7}$; $\alpha = 0.003674$	
4 359.6	274.30
5 462.3	270.44
5 893	269.68
6 709.7	268.31
67 094	264.30
86 784	265.03
III (18)	
4 800	273.66
5 085	272.72
5 209	272.37
5 461	271.70
5 770	271.02
5 790	270.98
6 438	269.88
6 708	269.52

* At −189.9°C, λ = 5461 Å, and $54 < p < 372$ mm of Hg, $(n - 1)10^6 = 1.185p$ (3). At 20°C, λ = 5461 Å, and d between $50d_0$ and $200d_0$, d_0 = density at 0°C and 760 mm, $(n^2 - 1)d_0/(n^2 + 2)d$ $(= 181.4 \times 10^{-6})$ is more nearly constant than either $(n^2 - 1)/d$ or $(n - 1)/d$ (57).

O_3, Ozone

λ	r_0
III (18)	
4 800	532.90
5 085	526.21
5 209	523.75
5 461	520.00
5 770	516.24
5 790	515.14
6 438	509.68
6 708	507.64

P_2, Phosphorus

III (10)	
5 893	1 197

Rb, Rubidium*

* For dispersion near absorption bands, *see* Bevan (5).

S_2, Sulfur

III (10)	
5 893	1 101

Se_2, Selenium

III (20)	
5 461	1 570
5 540	1 560
5 893	1 565
6 540	1 530
6 562	1 535

Te_2, Tellurium

III (20)	
5 461	2 620
5 893	2 495
6 562	2 370

Xe, Xenon

III (16)	
4 799.9	712.8
5 085.8	709.2
5 209.1	707.9
5 460.7	705.5
5 769.5	702.9
5 790.5	702.8
6 438.5	698.7
6 707.8	697.3

Zn_2, Zinc

III (20)	
5 183	2 070
5 461	2 150
5 630	2 020
5 893	2 050
5 893	2 065
6 562	1 960

II. 𝔅-Table.—Chemical Compounds, Standard Arrangement; *v.* Vol. III, p. viii

H_2O, Water

λ	r_0
III (18)	
4 799.9	254.95
5 085.8	253.80
5 209.1	253.45
5 460.7	252.70
5 769.5	251.95
5 790.5	251.91
6 438.5	250.69
6 707.8	250.28

HCl, Hydrochloric acid

λ	r_0
III (18)	
4 799.9	451.87
5 085.8	450.07
5 209.1	449.30
5 460.7	448.00
5 769.5	446.66
5 790.5	446.56
6 438.5	444.44
6 707.8	443.75

HBr, Hydrobromic acid

III (18)	
4 799.9	621.60
5 085.8	618.24
5 209.1	617.04
5 460.7	614.90
5 769.5	612.56
5 790.5	612.45
6 438.5	608.78
6 707.8	607.52

HI, Hydriodic acid

λ	r_0
III (18)	
4 799.9	939.00
5 085.8	932.57
5 209.1	930.15
5 460.7	925.80
5 769.5	921.06
5 790.5	920.87
6 438.5	913.34
6 707.8	910.87

SO_2, Sulfur dioxide

III (15)	
5 000	668.63
5 461	663.97
5 800	661.26
6 500	657.10
6 700	656.40
I (77)	
4 359	696.3
5 461	682.0
6 708	660.6
*III** (31)	
5 350	665.5
5 889	661.0
6 707	656.7
(79)	
5 893	676

* Reduced to this basis by Cuthbertson (15).

SO_3, Sulfur trioxide

III (19)	
5 893	737

H_2S, Hydrogen sulfide

III (15)	
4 861	650.98
5 461	644.03
5 790	641.17
6 563	636.22

SF_6, *I* (63)

5 893	783

SeF_6, *I* (63)

5 893	895

TeF_6, *I* (63)

5 893	991

NO, *III* (18)

4 799.9	297.76
5 085.8	296.66
5 209.1	296.22
5 460.7	295.50
5 769.5	294.74
5 790.5	294.68
6 438.5	293.44
6 707.8	293.06

NO_2, *I* (17)

6 438	508.7

N_2O_4, *I* (17)

6 438	1 123

N_2O, *III* (18)

λ	r_0
4 799.9	514.15
5 085.8	512.08
5 209.1	511.45
5 460.7	510.00
5 769.5	508.57
5 790.5	508.48
6 438.5	506.16
6 707.8	505.44
(50)*; *cf.* (83)	
4 800.2	523.0
5 086.1	520.7
5 378.9	519.2
6 439.2	513.2

* Gas not pure.

NH_3, *III (18)**

4 799.9	383.00
5 085.8	380.83
5 209.1	380.02
5 460.7	378.60
5 769.5	377.07
5 790.5	377.01
6 438.5	374.55
6 707.8	373.76
I† (47)	
$\alpha = 0.00390$	
4 358	396.1
4 861	391.8
5 461	387.0
5 875	384.8
6 563	382.6

* Data given with reserve.

† Reduced to 0°C and 760 mm by using $\alpha = 0.003914$, then reduced this value to what it would be if $(n - 1)/p$ were constant and p had such a value that the number of formula-weights per unit volume was equal to the number of moles of H_2 per unit volume at 0°C and 760 mm. These would agree with the following data (47) if reduced in the same way.

PH_3 (24)

White	789

PCl_3 (51)

5 893	1 740

CO; *cf.* (83)

I (11)	
4 800	339.20
5 085	337.82
5 209	337.32
5 461	336.40
5 770	335.42
5 790	335.35
6 438	333.79
6 708	333.27
(28)	
4 472	340.8
4 713	339.4
4 922	338.3
5 016	337.9
5 876	334.9
6 678	333.4
I (35, 38)	
$\alpha = 0.003667$	
2 379	386.7
2 448	382.3
2 465	381.3
2 536	377.4
2 577	375.4
2 676	371.0

CO.—(*Continued*)

λ	r_0
2 754	368.0
2 761	367.7
2 858	364.4
2 894	363.3
2 926	362.3
2 968	361.2
3 342	353.0
3 545	349.8
3 681	347.9
3 861	345.8
3 985	344.6
4 109	343.4
4 359	341.6
4 917	338.3
5 462	336.0
5 893	334.9
67 094	332.5
86 784	332.5

(60)

4 679	338.7
4 801	338.2
5 087	336.8
5 380	335.7
5 896	334.2
6 440	332.8

I (48)

$\alpha = 0.00367$

4 801	338.9
5 087	337.4
5 380	336.3
5 896	335.0
6 440	333.9

(84)

5 890	334.8
8 000	330.9
10 000	329.5
20 000	326.9
22 500	327.3
23 500	327.6
24 500	327.7
27 000	326.3
30 000	325.1
35 000	323.0
38 000	322.3
40 000	318.1
41 500	315.9
42 000	316.9
43 000	305.2
44 000	294.9
44 500	288.1
45 000	282.1
45 500	272.9
47 500	378.9
48 000	374.6
49 000	359.8
50 000	350.8
51 000	347.4
52 000	343.6
54 000	340.1
56 000	338.0
58 000	336.2
63 000	333.7
70 000	333.7

CO.—(*Continued*)

λ	r_0
80 000	330.7
90 000	331.2
130 000	328.0

CO_2, *I** (11)

$\alpha = 0.00371$

λ	r_0
4 800	453.42
5 085	452.01
5 209	451.48
5 461	450.50
5 770	449.47
5 790	449.40
6 438	447.71
6 708	447.14

III† (11)

4 800	449.99
5 085	448.58
5 209	448.06
5 461	447.10
5 770	446.08
5 790	446.01
6 438	444.34
6 708	443.77

I (29)

2 753	476.17
2 894	471.37
3 022	469.29
3 188	465.49
3 820	456.38
4 026	454.14
4 471	451.19
4 713	449.06
5 016	447.50
5 876	445.31
6 678	443.79

I (35, 38); *cf.* (34)

$\alpha = 0.003716$

2 379	497.30
2 448	493.70
2 465	492.86
2 536	489.55
2 577	487.80
2 676	483.98
2 754	481.31
2 760	481.09
2 858	478.13
2 926	476.22
2 968	475.18
3 342	467.45
3 545	464.41
3 681	462.49
3 861	460.46
3 985	459.32
4 109	458.17
4 360	456.27
4 917	452.89
5 461	450.56
5 893	449.16
6 709	447.07
67 094	480.38
86 784	457.92

CO_2.—(*Continued*)

λ	r_0
I (77)	
4 359	458.9
5 461	451.1
6 708	446.6

II‡ (61)

4 358	456.68
5 461	450.88
5 790	449.54

I (76)

$\alpha = 0.003716$

5 893	450.8
8 000	446.3
10 000	441.4
20 000	433.6
30 000	418.5
40 000	289.0
50 000	531.6
67 000	483.8
87 000	458.0
110 000	447.2
131 900	400.4

(57)

$t = 21°C$, $\lambda = 5461$ Å

d/d_0§	$(n-1)10^6$§
27	1 216_0
35	1 581_0
45	2 034_0
60	2 715_0
70	3 169_0

(3)

$t = -78.3°C$, $\lambda = 5461$ Å

p, cm	$(n-1)10^6$
9.3	77.5
16.6	138.0
20.6	171.0
50.7	423.3
51.0	422.4
53.0	441.8
62.4	522.1
73.0	609.9
73.4	611.0
76.1	633.0
76.1	623.5
76.6	643.4
81.1	682.9
85.4	699.0

$(n-1)10^6 = 8.31_6p$

For $\lambda = 5780$ Å

$(n-1)10^6 = 8.29_3p$

(62)

5 461	451.55

For $p < 760$ mm

$K = 0.5519$

$10^6\gamma = 10.63 \pm 0.55$

CO_2.—(*Continued*)

(58)

760 mm $< p <$ 7600 mm

For $\lambda = 5462$ Å

$K = 0.5468$

$10^6\gamma = 8.72 \pm 0.32$

For $\lambda = 4359$ Å

$K = 0.5533$

$10^6\gamma = 8.71 \pm 0.30$

(84)

λ	r_0
5 890	454.3
8 000	451.6
10 000	450.0
20 000	441.1
24 000	435.1
25 000	431.9
26 000	428.7
26 500	427.4
27 000	429.5
27 500	431.6
28 000	432.2
29 000	426.9
30 000	423.2
33 000	405.2
36 000	375.0
38 000	329.5
39 000	288.0
40 000	217.0
40 500	139.0
41 000	+ 92.0
42 000	−238.0
43 500	+974.0
44 000	834.0
44 500	696.0
45 000	670.7
46 000	617.6
47 000	584.9
49 000	548.1
52 000	523.6
56 000	507.0
62 000	492.0
70 000	483.2
80 000	472.7
90 000	468.2
100 000	457.7
110 000	445.5
122 000	423.8
132 000	371.0
137 500	317.0

* Also corrected for factor A in $[(PV)_{760} - (PV)]/(PV) = A(P - 760)$, using $A = 10.2 \times 10^{-6}$ per mm of Hg.

† Derived from same observations as preceding data.

‡ At 34°C, $\lambda = 5461$ Å, $0.10 < d < 0.74$, $\left(\frac{n^2+2}{n^2-1}\right)d = 6.581(1 + 0.0172 \times d^2)$.

§ $(n^2-1)/(n^2+2)d$ is more nearly constant than either $(n^2-1)/d$ or $(n-1)/d$; d_0 = density at 0°C and 760 mm of Hg.

C-Compounds.—C-Arrangement; *v.* Vol. III, p viii

CCl_2O, Carbonyl chloride (24)

λ	r_0
White	1 159

CCl_4, Carbon tetrachloride (50,* 52)

5 893	1 779

CS_2, Carbon disulfide (51)

5 893	1 485
(43)	
5 893	1 478
6 710	1 457

$CHCl_3$, Chloroform (50,* 52)

5 893	1 464
(43)	
5 893	1 442
6 708	1 435

CHN, Hydrocyanic acid (51)

5 893	438

CH_3Br, Methyl bromide (50,* 52)

5 893	964

CH_3Cl, Methyl chloride (50,* 52)

5 893	870

CH_3F, Methyl fluoride (10)

5 893	449

CH_3I, Methyl iodide (50,* 52)

5 893	1 273
(64)	
5 893	1 265
6 708	1 253

CH_4, Methane

I (44, 46)	
5 290	447.8
5 718	445.4
5 935	443.5
6 375	441.1
6 585	440.4
(30)	
4 359	450.5
5 461	443.5
5 780	441.9
6 435	438.7
I (35) $\alpha = 0.003670$	
4 359	447.5
5 461	440.7
5 895	439.1
6 709	436.7
65 570	419.2
86 784	450.1

CH_4O, Methyl alcohol (50,* 52)

5 893	623
(64)	
5 893	552
6 708	550

* Data given with reserve.

C_2N_2, Cyanogen (31.1)

λ	r_0
5 350	789
5 893	784
6 708	780
I (77)	
4 359	870.8
5 461	853.8
6 708	843.1
II (9)	
5 893	844.6
(48)	
5 893	820.2

C_2H_2, Acetylene

I (44, 46)	
5 461	569.8
5 769	566.3
5 896	565.1
6 375	562.7
6 708	560.4
I (77)	
4 359	619.0
5 461	605.1
6 708	597.7
(52)	
5 893	610

C_2H_3N, Acetonitrile (50,* 52)

5 893	776

C_2H_4, Ethylene

I (45)	
5 230	662.0
5 461	661.4
5 790	658.8
5 896	657.1
6 185	653.1
6 677	651.6
(30)	
4 359	739.4
5 461	720.3
5 780	716.9
6 435	713.1
I (77)	
4 359	742.8
5 461	731.5
6 708	716.8

$C_2H_4Cl_2$, 1, 1-Dichloroethane (64)

5 893	1 415
6 708	1 408

$C_2H_4Cl_2$, Ethylene chloride (50,* 52)

5 893	1 417
(64)	
5 893	1 349
6 708	1 341

C_2H_4O, Acetaldehyde (50,* 52)

5 893	811

* Data given with reserve.

C_2H_5Br, Ethyl bromide

λ	r_0
(50,* 52)	
5 893	1 223

C_2H_5Cl, Ethyl chloride (50,* 52)

5 893	1 179

C_2H_5I, Ethyl iodide (50,* 52)

5 893	1 608
(43)	
5 893	1 646
6 708	1 632

C_2H_6, Ethane

I (45, 46)	
5 230	756.8
5 461	756.6
5 790	754.2
5 896	752.8
6 185	750.9
6 677	747.8
I (77)	
4 359	782.4
5 461	769.0
6 708	762.9

C_2H_6O, Ethyl alcohol (50,* 52)

5 893	885
(43)	
5 893	873
6 708	868

C_2H_6O, Methyl ether (50,* 52)

5 893	891

C_3H_4, Allylene (50,* 52)

5 893	1 188

C_3H_5Cl, 3-Chloropropylene (50,* 52)

5 893	1 444

C_3H_6, Propylene (50,* 52)

5 893	1 120

C_3H_6O, Acetone (50,* 52)

5 893	1 100
(64)	
5 893	1 082
6 708	1 076

* Data given with reserve.

$C_3H_6O_2$, Ethyl formate

λ	r_0
(50,* 52)	
5 893	1 191
(64)	
5 893	1 199
6 708	1 193

$C_3H_6O_2$, Methyl acetate (50,* 52)

5 893	1 138
(64)	
5 893	1 193
6 708	1 187

C_3H_7I, Propyl iodide (64)

5 893	1 788
6 708	1 775

$C_4H_8O_2$, Ethyl acetate (50,* 52)

5 893	1 408
(43)	
5 893	1 586
6 708	1 578

$C_4H_8O_2$, Methyl propionate (64)

5 893	1 477
6 708	1 469

$C_4H_{10}O$, Ethyl ether (50,* 52)

5 893	1 544
(43)	
5 893	1 521
6 708	1 514

C_5H_{10}, Amylene (50,* 52)

5 893	1 693

C_5H_{12}, Pentane (50,* 52)

5 893	1 711

C_6H_6, Benzene (50,* 52)

5 893	1 823
(80)	
5 893	1 820
(64)	
5 893	1 705
6 708	1 691

* Data given with reserve.

Mixtures

x = vol. % of second substance (or mixture); subscripts $_{\text{mix.}}$, $_1$, and $_2$, refer to the mixture and to first and second substance, respectively. The refractivities are said to be additive if $(n-1)_{\text{mix.}} = (n-1)_1 + x\{(n-1)_2 - (n-1)_1\}$. Reduced refractivity and density of the mixture are defined as $(n-1)_r = (n-1) \times \frac{760}{p} \cdot \frac{T}{273}$ and $d_r = d \cdot \frac{760}{p} \cdot \frac{T}{273}$.

Mixture	λ	Remarks	Lit.
Air................		*See* Tables 1, 2, 3	
$O_2 + O_3$..........	4800 to 6708	Additive	(18)
$NO_2 + N_2O_4$.......	6438	$10^6(n-1)_r = 298.34d_r - 105.33$*	(17)
$H_2 + CO_2$	5780	Additive	(78)
$H_2 + (He + Ne)$....	5780	Additive	(78)

* 272°K < T < 343°K; 55 mm < p < 238 mm.

TABLE 5.—DISPERSION FORMULAE FOR GASES AND VAPORS

$\lambda_\mu = 10^{-4}\lambda_A$; unit of $\lambda_A = 1$ Å. The table is divided into 4 sections, each, except *D*, devoted to a single type of formula. In general, the data refer to 0°C and 760 mm of Hg. Certain of the parameters depend upon the formula used in reducing the observations to 0° and 760 mm; these formulae are indicated by *I*, *II*, *III* (*see* Table 4) placed at head of section or in column (2).

A. $(n-1)10^6 = A + B\lambda_\mu^{-2} + C\lambda_\mu^{-4}$ (Formula *I*)

(1)	*A*	*B*	*C*	1000*B*/*A*	$10^6C/A$	Lit.
A	277.826	1.558	0	5.608	0	(65)
H_2*	136.102	1.0246	0.009906†	7.5282	72.78	(33)
H_2				7.337‡	89‡	(69, 72, 74)
O_2	269.74	0.372	0.126	1.379	467	(66)
CO_2				6.787§	−6.14§	(70, 71, 73)
Air	*See* Table 2					

* Those authors who use only *A* and *B*, find values of *B* varying from 0.90 to 1.00; *see* (14).

† Author uses a fourth term, $D\lambda_\mu^{-6}$; $D = 70.51 \times 10^{-6}$, $D/A = 5.181 \times 10^{-7}$.

‡ For all pressures between 25 and 70 atmospheres, $t = 20$°C, 4050 Å $< \lambda <$ 5090 Å.

§ For all pressures between 20 and 47 atmospheres, $t = 12$°C, 4050 Å $< \lambda <$ 5090 Å.

B. $(n-1)10^6 = \beta'/(\mu' - \lambda_\mu^{-2}) + \beta''/(\mu'' - \lambda_\mu^{-2})$

In most cases, β'' and $\mu'' = 0$; when β'' and μ'' are not zero, their values are written below those of β' and μ', with which they are connected by {.

(1)	(2)	β	μ	Lit.
A	*III*	52 404	188.99	(16)
Br_2	*III*	47 598	43.547	(18)
Cl_2	*III*	81 257	106.993	(18)
H_2	*I*	18 800	137.88	(14)
H_2	*I*	12 200.7 5 811.98	118.637 175.327	(33)
He	*III*	13 470.9	388.80	(16)
Kr	*III*	59 385	141.866	(16)
N_2	*I*	55 939	189.94	(14)
Ne	*III*	28 814	432.40	(16)
O_2	*I*	37 744	142.27	(14)
Xe	*III*	68 010	99.754	(16)
H_2O	*III*	29 190	118.86	(18)
HCl	*III*	51 583	118.49	(18)
HBr	*III*	57 162	96.316	(18)
HI	*III*	64 333	72.849	(18)
SO_2	*III*	63 640	99.21	(15)
H_2S	*III*	53 711	86.76	(15)
NO	*III*	39 122	135.73	(18)
N_2O	*III*	62 983	126.84	(18)
NH_3	*III*	32 953	90.392	(18)
NH_3	*I*	30 998	83.442	(47)
CO	*III*	40 452	123.60	(11)
CO_2	*I*	69 049	156.63	(11)
CO_2	*III*	68 524	156.63	(11)

C. $\frac{3}{2}\left(\frac{n^2-1}{n^2+2}\right)10^6 = \beta'/(\mu' - \lambda_\mu^{-2}) + \beta''/(\mu'' - \lambda_\mu^{-2})$ (Formula *I*)

(1)	β'	μ'	β''	μ''	Lit.
N_2	39 534	152.294	−8 373.4*	−240.651*	(37)
CO_2	74 203	172.400	485.22	45.038	(38)

* Note the minus sign here.

D. Miscellaneous formulae

H_2	*I*	$(n^2-1)10^6 = 272.16 + 2.112/(\lambda_\mu^2 - 0.00776)$ (35)
He	*I*	$\frac{2}{3}\cdot\frac{n^2+2}{n^2-1} = 28\,860.8 - \frac{67.763}{\lambda_\mu^2}$ (37)
O_2	*I*	$(n^2-1)10^6 = 528.42 + 3.696/(\lambda_\mu^2 - 0.007000)$* (35)

* After correcting misprints in original article.

TABLE 6.—INDEX OF REFRACTION OF ISOTROPIC, NON-METALLIC SOLID AND LIQUID ELEMENTARY SUBSTANCES

Double refracting solids, p. 16; metals, Vol. V, p. 248. n = index of refraction; l = liquid; s = solid. Unit of $\lambda = 1\mu = 10^{-4}$ cm. Temperature = t, °C.

(1)	λ	n	t	Lit.
Br *l*	*D*0.589	1.661	15	(29)
Cl *l*	*D*0.589	1.385	20	(22)
Cl *l*	*D*0.589	1.367	14	(6)
H *l*	0.579	1.0974	−252.83	(2)
I *s*	*D*0.589	3.34		(55)
N *l*	0.579	1.1975	−195.83	(2)
N *l*	*D*0.589	1.2053	−190	(40)
O *l*	*D*0.589	1.221	−181	(41, 42)
P *s**	*D*0.589	2.1442	25	(27)
S *s*†	*D*0.589	1.998		(56)
S *l*	*D*0.589	1.929	110	(4)
S *l*	*D*0.589	1.890	130	(4)
Se *s*†	*D*0.589	2.92		(56)

* Yellow P. † Amorphous.

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REFRACTIVITY OF SELECTED SOLIDS AND LIQUIDS

CHARLES CHÉNEVEAU

Scope.—The substances included in this section are those pure solids and liquids which have been studied with special care on account of their practical importance or of some unusual behavior. All are listed in Table 1.

Sujet traité.—Les substances mentionnées dans cette section, sont les solides et liquides purs qui ont été étudiés avec un soin spécial, soit à cause de leur importance pratique, soit à cause de leur façon de se comporter inaccoutumée. Elles sont toutes mentionnées dans la Table 1.

Umfang.—Die in diesem Abschnitt enthaltenen reinen festen und flüssigen Stoffe sind solche, welche zufolge ihrer praktischen Bedeutung oder ihres ungewöhnlichen Verhaltens mit besonderer Sorgfalt studiert worden sind. Alle sind in der Tafel 1 angeführt.

Sostanze incluse.—Le sostanze incluse in questo capitolo sono quei solidi e liquidi puri che sono stati studiati con cura speciale sia per la loro importanza pratica o per il loro anormale comportamento. Essi sono riuniti nella Tabella 1.

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Remarkable cubic crystals.	Cristaux cubiques remarquables.	Besondere kubische Kristalle.	Cristalli cubici speciali.....	13
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Units.—Unit of $\lambda = 1\mu = 10^4$ Å $= 10^{-4}$ cm; of $t = 1°$C; of $p = 1$ atm.; of $d =$ g/cm.^{3}

TABLE 1.—REFRACTIVITY OF PURE SOLIDS AND LIQUIDS: SELECTED SUBSTANCES

$N_D[n_D]$ = index of refraction relative to vacuum [to air at 1 atm. and same temperature as the substance] for the Fraunhofer line D ($\lambda = 0.5893\mu$); similarly for n_C, n_F, etc.; $(10)^{-4}\,\Delta_{C-D} = (n_C - n_D)/(\lambda_C - \lambda_D)$, etc.; $(10)^{-5}\,\Delta_{tD} = (n_{t''} - n_{t'})/(t'' - t')$ for $\lambda = 0.5893(D)$; Δ_λ = mean value of $dn/d\lambda$ throughout visible spectrum; $dn/dt = A_t(10)^{-6}$; $dN/dp = A_p(10)^{-6}$; C = crystal of cubic system; d = density; f = solidified from fusion; s = solid. Temperature (t) is 20°C, except as noted; $\lambda_C - \lambda_D = 0.0670\mu$, $\lambda_D - \lambda_F = 0.1032\mu$, $\lambda_F - \lambda_{G'} = 0.0520\mu$.

Substance			n_D	$-\Delta_{C-D}$	$-\Delta_{D-F}$	$-\Delta_{F-G'}$	Lit.	$-\Delta_{tD}$	t', °C	t'', °C	Lit.
H_2O	Water (*see* Table 2).............		1.3330	276	401	617		8	10	25	
NH_4Cl	Sal ammoniac..................	*s*	1.6422	$\Delta_\lambda = -0.109$			(21)				
C	Diamond* (15°C)...............	*s*	2.4173		1747		(67)	$(A_t)_D$, 18° = +19			(56)
CCl_4	Carbon tetrachloride............		1.460	402	649	1057	(63)	50	11.1	25	(7)
CS_2	Carbon disulfide†..............		1.629	1401	2412	4269	(6)	79	−20	+40	(26)
$CHCl_3$	Chloroform....................		1.446	373	610	1038	(33)	55	18	30	(20)
CH_2O_2	Formic acid....................		1.371	328	465	711	(23, 29)	43	19	21	(28)
CH_3I	Methyl iodide..................		1.530	805	1230	2192	(22)	78	16	29.5	(20)
CH_4O	Methyl alcohol.................		1.329	239	368	576	(9, 30)	36	18	30	(20)
$C_2H_4Br_2$	Ethylene bromide...............		1.540	597	978	1634	(63)	57	0	35	(69)
C_2H_4O	Acetaldehyde...................		1.333	268	416	673	(22, 28)	60	6	12	(28)
$C_2H_4O_2$	Acetic acid....................		1.372	298	445	711	(11, 15, 24)	51	18	26	(15)
C_2H_5I	Ethyl iodide...................		1.513	686	1133	1923	(22, 24)	69	10	20	(33)
C_2H_6O	Ethyl alcohol‡.................		1.361	268	416	653	(54)	40	0	45	(27)
C_3H_6O	Acetone§......................		1.359	283	455	750	(6, 24)	53	0	45	(27)
C_3H_8O	Isopropyl alcohol..............		1.377	283	436	692	(4)				
$C_3H_8O_3$	Glycerol‖......................		1.474¶	343**	532**	846**	(29, 32)	20	18	22	(29)
$C_4H_8O_2$	Butyric acid...................		1.398	313	475	788	(4)	40	19	21.7	(65)
$C_4H_{10}O$	Butyl alcohol..................		1.399	298	475	711	(4)	41	15.5	80.2	(16)
$C_4H_{10}O$	Ethyl ether††..................		1.352	268	416	634	(6, 9)	59	0	35	(38)
$C_5H_{12}O$	Isoamyl alcohol................		1.407	313	484	750	(4)	40	16	26	(9)
$C_6H_5NO_2$	Nitrobenzene...................		1.553	1044	1773		(4)	51	25	38	(20)
C_6H_6	Benzene†......................		1.501	701	1162	2000	(6)	64	12	30	(69)
C_6H_6O	Phenol........................		1.550	880	1279	2307	(29)				
C_6H_7N	Aniline.......................		1.586	1013	1753	3153	(4)	54	11.2	90.1	(41)
C_7H_8	Toluene‡‡.....................		1.495	656	1114	1923	(6)	58	10	90	(41)
C_8H_{10}	*o*-Xylene†....................		1.507	656	1104	1884		57	11	42	(5)
$C_8H_{10}N_2O$	*p*-Nitrosodimethylaniline........	*s*	1.808		§§		(10)				
$C_{10}H_7Br$	Bromonaphthalene‖‖...........		1.658	1313	2296	4211	(6)	46	16.5	77.6	(37)
$C_{20}H_{20}ClN_3$	Fuchsin.......................	*s*	2.64	*See* Table 5			(42, 44)				
$C_{23}H_{25}ClN_2$	Malachite green................	*s*	1.33	*See* Table 5			(42)				
$C_{26}H_{32}ClN_3$	Hofmann violet................	*s*	2.20	*See* Table 5			(42, 46)				
$C_{27}H_{18}N_4O_8S$	Diamond green.................	*s*	1.27	*See* Table 5			(43, 46)				
$C_{29}H_{35}IN_2.\frac{3}{2}H_2O$	Cyanin........................	*s*	1.71	*See* Table 5			(42, 43)				
$C_{30}H_{20}N_4.HCl$	Magdala red...................	*s*	1.90	*See* Table 5			(42)				

TABLE 1.—(*Continued*)

Substance		Form	t, °C	n_D	$-\Delta_\lambda$	Lit.
SiO_2; *see* Vol. VI, p. 341						
$Pb(NO_3)_2$¶¶	*s*	*C*		1.7820	0.197	(64)
AgCl	*s*	*f,C*		2.061	0.290	(70)
AgBr	*s*	*f,C*		2.253	0.470	(70)
AgI	*s*	*f,C*		2.181	0.740	(70)
$(NH_4)_2SO_4.Fe_2(SO_4)_3.24H_2O$	*s*	*C*		1.4848	0.081	(59)
$(NH_4)_2SO_4.Cr_2(SO_4)_3.24H_2O$	*s*	*C*		1.4841	0.065	(59)
B_2O_3	*s*	*f*	15	1.4636	0.042	(1.1)
$(NH_4)_2SO_4.Al_2(SO_4)_3.24H_2O$*	*s*	*C*	15 to 21	1.4594	0.052	(59)
CaF_2*	*s*	*C*	18	1.4338	0.0284	(36, 55)
$Ba(NO_3)_2$	*s*	*C*		1.5711	0.095	(64)
NaCl*	*s*	*C*	18	1.5443	0.0804	
$NaClO_3$*	*s*	*C*	19	1.5152	0.0458	(3)
$Na_2B_4O_7$	*s*	*f*	16	1.5147	0.070	(1.1)
$Na_2SO_4.Al_2(SO_4)_3.24H_2O$	*s*	*C*		1.4388	0.044	(59)
KCl*	*s*	*C*	18	1.4904	0.0705	
KBr	*s*	*C*		1.5593	0.100	(64)
KI	*s*	*C*		1.6666	0.169	(64)
$K_2SO_4.Fe_2(SO_4)_3.24H_2O$	*s*	*C*		1.4816	0.078	(59)
$K_2SO_4.Cr_2(SO_4)_3.24H_2O$	*s*	*C*		1.4813	0.0638	(59)
$K_2SO_4.Al_2(SO_4)_3.24H_2O$*	*s*	*C*	21	1.4560	0.052	(59)

* *See also* Table 3.

† *See also* Table 4.

‡ For 99.7 to 99.9 % C_2H_5OH. For pure C_2H_5OH, $n^2 = 1.839 + \frac{0.006795}{\lambda^2 - 0.01716}$ if $0.215\mu < \lambda < 0.420\mu$. If $t' = 0°$ and $t'' = 45°$, $\Delta_{tC} = -40.3$, $\Delta_{tD} = -40.4$, $\Delta_{tF} = -41.0$, $\Delta_{tG'} = -41.5$ (27). If $\lambda = 0.5893$ (D), $A_p = +40$ at 10°; +42, 20°; +44, 25°; +45, 27.5° (48).

§ If $t' = 0°$ and $t'' = 45°$, $\Delta_{tC} = -52.8$, $\Delta_{tD} = -53.0$, $\Delta_{tF} = -53.8$, $\Delta_{tG'} = -54.9$ (27).

‖ If $\lambda = 0.5893$ (D), $A_p = +11$ at 20°C (26).

¶ For pure $C_3H_8O_3$; deduced by extrapolation from 94.6 % $C_3H_8O_3$.

** For glycerol of $d = 1.259$ g cm^{-3} at 20°C.

†† If $\lambda = 0.5893$ (D), $A_p = +60$ at 5°; +63, 10°; +69, 20°; +72, 25°; +75, 27.5°C (48).

‡‡ If $t' = 10°$ and $t'' = 90°$, $\Delta_{tC} = -57.2$, $\Delta_{tD} = -57.7$, $\Delta_{tF} = -59.2$ (41).

§§ p-Nitrosodimethylaniline, p-$(CH_3)_2NC_6H_4NO$, at 20°C (10):

λ	0.4878	0.5042	0.5189	0.5270(E)	0.5603	0.5857	0.6170	0.6497
n	2.146	2.024	1.957	1.926	1.847	1.813	1.785	1.762

‖‖ If $t' = 16.5°$ and $t'' = 77.6°$, $\Delta_{tC} = -45.4$, $\Delta_{tD} = -46.1$; $\Delta_{tF} = -47.8$ (37).

¶¶ Isotopic $Pb(NO_3)_2$ at 20°C. Pb = 207.20, $n_D = 1.7815$; Urano-Pb = 206.41, $n_D = 1.7814$ (47).

TABLE 2.—REFRACTIVITY OF WATER (H_2O)

Variation with wave-length (λ), with temperature (t) and pressure (p), and with source. $N[n]$ = index of refraction with reference to vacuum [to air at 1 atm. and same temperature as the water]; met. r. = metallic reflection.

Variation with λ: Except as noted, $t = 20°C$. At 18°C, $n^2 = -0.013414\lambda^2 + 1.76148 + \frac{0.0065438}{\lambda^2 - (0.11512)^2}$, if $0.224\mu < \lambda < 1.256\mu$.

Radiation		n	Radiation		n
S	λ		S	λ	
(12)			(17, 34, 57)		
	0.1151	met. r.	Cd	0.2144	1.4039_7
Ag	0.1829	1.4637_9	Cd	0.2195	1.3988_3
Al	0.1862	1.4534_3	Cd	0.2265	1.3925_7
Al	0.1990	1.4257_2	Cd	0.2313	1.3887_8
(17, 34, 57)			Mean of many observers		
Au	0.2428	1.3810_3	Hg	0.5770	1.33342
Cd	0.2573	1.3734_9	Hg	0.5790	1.33333
Au	0.2676	1.3690_4	Na(D)	0.5893	1.33300
Cd	0.2749	1.3663_7	Hα(C)	0.6563	1.33115
Al	0.3082	1.3567_1	Li	0.6708	1.33079
Cd	0.3404	1.3504_4	K(A')	0.7682	1.32888
Cd	0.3611	1.3473_8	(49)		
Mean of many observers				0.871	1.3270
Al	0.3944	1.3436_6		0.943	1.3258
Ca(H)	0.3968	1.34352		1.028	1.3245
Hγ(G')	0.4341	1.34035		1.130	1.3230
Hg	0.4360	1.34030		1.256	1.3210
Cd	0.4416	1.33981	Residual rays (51)		
Cd	0.4678	1.33815	CaF_2	25.5 to 26	1.41
Cd	0.4800	1.33750	NaCl	49.6 to 53.6	1.36
Hβ(F)	0.4861	1.33714	KBr	75.6 to 86.5	1.41
Cd	0.5338	1.33499	Electromagnetic (62)		
Tl	0.5350	1.33490		4 000	5.3
Hg	0.5460	1.33447		27 000	9.0

Variation with temperature (t) and pressure (p): $n_t = n_{20} - 10^{-5} \times [0.124(t - 20) + 0.1993(t^2 - 400) - 0.000005(t^4 - 160\ 000)]$; $dn/dt = A_t(10)^{-6}$ (mean result of many observers). Values of dN/dp apply if 1.5 atm. $< p <$ 8 atm.; $dN/dp = A_p(10)^{-6}$.

λ	0.4341	0.4861	0.5893	0.6563		0.5893
t	$n_{G'}$	n_F	n_D	n_C	$-A_t$	A_p*
−10	(Liquid H_2O)		1.3338†			(46, 48, 72)
0			1.3340		1	+16.8
+ 5			1.3339			+16.2
10	1.3411	1.3378	1.3337	1.3318	41	+15.8
15			1.3334			+15.4
20	1.34035	1.33714	1.33300	1.33115	79	+15.2
25			1.3325			+14.8
30	1.3392	1.3360	1.3320	1.3302	115	
40	1.3379	1.3347	1.3306	1.3288	148	
50	1.3364	1.3332	1.3290	1.3274	176	
60	1.3346	1.3315	1.3272	1.3257	197	
70	1.3325	1.3294	1.3252	1.3237	212	
80			1.3231		218	
90			1.3207			

Variation with source of water: Natural waters at 20°C (13, 60). For $\lambda = 0.5893$ (D), n is as follows: Pure distilled H_2O, 1.33300; city supply, Paris, 1.33304; river, Seine, 1.33305; ocean, Mediterranean, 1.337; H_2O saturated with CO_2 at 1 atm., 1.33297.

*At 18.2°C			
	λ = 0.486	0.589	0.686
	A_p = 15.4	15.2	15.1

† For liquid (undercooled) H_2O, n_D passes through a maximum (1.33412) between −1°C and −2°C (45).

TABLE 3.—REFRACTIVITY OF SOME REMARKABLE CUBIC CRYSTALS

Includes: Sylvite (KCl), rock salt (NaCl), fluorite (CaF_2), sodium chlorate ($NaClO_3$), diamond (C), ammonium alum [$Al_2(SO_4)_3.(NH_4)_2SO_4.24H_2O$] and potassium alum [$Al_2(SO_4)_3.K_2SO_4.24H_2O$]. For SiO_2, *see* Vol. VI, p. 341. n = index of refraction with reference to air at 1 atm. and same temperature as crystal; $A_t(10)^{-6} = dn/dt$; abs. = strong absorption; met. r. = metallic reflection. $n^2 = -k'(10)^{-7}\lambda^4 - k(10)^{-4}\lambda^2 + a + \frac{b_1(10)^{-3}}{\lambda^2 - \beta_1^2} + \frac{b_2(10)^{-3}}{\lambda^2 - \beta_2^2}$ if $0.185\mu < \lambda < 22.30\mu$. $n^2 = n_\infty^2 + \frac{M_1}{\lambda^2 - \lambda_1^2} + \frac{M_2}{\lambda^2 - \lambda_2^2}$ if $\lambda' < \lambda < \lambda''$.

TABLE 3.—(*Continued*)

Parameter	18°C		
	KCl*	NaCl†	CaF$_2$
k'	1.67587	2.86086	28.94
k	5.13495	9.28584	32.055
a	2.174967	2.330165	2.03913
b_1	6.98382	5.343924	6.125
$100\beta_1^2$	2.555521	2.547407	0.0078925
b_2	8.344206	12.78635	
$100\beta_2^2$	1.190826	1.484985	
n_∞^2	4.5531	5.1790	6.0104
M_1	0.0150	0.018496	0.00612093
M_2	10 747	8 977	5 099.15
λ_1^2	0.0234	0.01621	0.008884
λ_2^2	4 517.1	3 149.3	1 258.47
λ'	0.434	0.434	0.185
λ''	22.30	22.30	9.4291

Radiation		KCl	NaCl		CaF$_2$	
S	λ	n	n	A_t	n	A_t
		(35)	(2, 8)	(36)	(19, 55)	(36)
Al	0.18540	1.82704	1.89322		1.50989	− 2.96
Al	0.19352	(abs.)	1.82800		1.50123	− 4.02
Al	0.19898	1.72432	1.79570		1.49621	− 4.64
Au	0.20821	1.68302	1.75403	+18.4	1.48885	− 5.82
Cd	0.21443	1.66182	1.73210	+ 8.51	1.48460	− 6.37
Cd	0.21946	1.64739	1.71700	+ 2.35	1.48150	− 6.55
Cd	0.23128	1.62037	1.68825	− 7.57	1.47516	− 7.32
Au	0.24280	1.60041	1.66699	−14.0	1.47009	− 7.70
Cd	0.25730	1.58119	1.64608	−19.79	1.46480	− 8.11
Cd	0.27486	1.56380	1.62690	−23.96	1.45967	− 8.55
Au	0.29136	1.55134	1.61312	−26.3	1.45586	− 8.90
Al	0.30821	1.54130	1.60190	−28.3	1.45257	− 9.21
Cd	0.30436	1.52720	1.58605	−30.68	1.44774	− 9.61
Cd	0.36117	1.52042	1.57842	−31.94	1.44535	− 9.79
			(35)		(55)	
Hδ(h)	0.41018	1.50901	1.56547	−33.4	1.44112	−10.04
Cd	0.44157	1.50384	1.55962	−34.25	1.43920	−10.28
Cd	0.50859	1.49614	1.55087	−35.17	1.43618	−10.56
Na(D)	0.58930	1.49038*	1.54433	−36.22	1.43385	−10.89
Li	0.67080	1.48663	1.54002	−36.5	1.43226	
K	0.76822	1.48374	1.53666		1.43093	
		(40)	(31, 39)		(31, 39)	
2D	1.1786	1.47821	1.53037		1.42786	
3D	1.7679	1.47579	1.52744		1.42502	
4D	2.3572	1.47465	1.52586		1.42198	
5D	2.9465	1.47373	1.52453		1.41822	
6D	3.5358	1.47295	1.52317		1.41379	
8D	4.7144	1.47102	1.51999		1.40238	
10D	5.8930	1.46870	1.51601		1.38719	
12D	7.0716	1.46591	1.51106		1.36805	
14D	8.2502	1.46263	1.50529		1.34444	
16D	9.4288	1.45875	1.49850		1.31612	
		(52, 53)	(52, 53)			
20D	11.786	1.44909	1.48182			
24D	14.143	1.43712	1.46055			
27D	15.911	1.42607	1.44103			
30D	17.679	1.41393				
	20.60	1.3882	1.3730			
	22.30	1.372	1.3403			
	51.2		(met. r.)			
	66.1	(met. r.)				
		(50)	(50)		(50)	
	57 000	2.17	2.40		2.60	
	τ‡	9.50	11.28		17.14	mm

TABLE 3.—(*Continued*)

Radiation		n			
		NaClO$_3$§	C,‖ 15°C	Al Alum¶	
S	λ			NH$_4$	K
		(t, 19°C) (3)	(35)	(t, 13°C) (3)	
Cd	0.21443			1.54349	1.53825
Cd	0.21946			1.53782	1.53280
Cd	0.22650			1.53106	1.52615
Cd	0.23128	1.61586		1.52684	1.52209
Cd	0.25730			1.50943	1.50514
Cd	0.27486			1.50096	1.49675
Cd	0.31332		2.5254		
Cd	0.3261	1.54931			
Cd	0.34036		2.5008	1.48180	1.47814
Cd	0.36117	1.53917	2.4853	1.47799	1.47436
			(67)	(t, 15 to 21°C) (58)	(t, 21°C) (61)
Ca(H)	0.39685		2.46476		1.46907
H(F, H_β)	0.48615		2.43539	1.46481	1.46140
Na(D)	0.58930	1.51523	2.41734**	1.45939	1.45602††
		(t, 23°C) (14)			
O(B)	0.6867	1.51163			
(a)	0.71734			1.45509	1.45175
O(A)	0.75938		2.40245		1.45057

* For KCl (35) at 18°C; $(A_t)_D = -35$. For visible spectrum, mean $dn/d\lambda = -0.0705$.

† In visible spectrum, mean $dn/d\lambda = -0.0804$.

‡ Thickness of plate used in finding n for the electromagnetic radiation ($\lambda = 57\ 000\mu = 5.7$ cm) is τ mm.

§ For NaClO$_3$ (14) $(n_{23°} - n_{0°})/23 = -57 \times 10^{-6}$ per 1°C if $0.686\mu > \lambda > 0.486\mu$.

‖ Diamond.

¶ In visible spectrum, mean $dn/d\lambda = -0.052$.

** For diamond (56) at 15°C, $(A_t)_D = +19$.

†† At 21°C (56) $(A_t)_D = -14$.

TABLE 4.—REFRACTIVITY OF SOME REMARKABLE ORGANIC LIQUIDS

$$n^2 = -k\lambda^2 + a + \frac{b_1}{\lambda^2 - \beta_1^2};\ n^2 = n_\infty^2 + \frac{M_1}{\lambda^2 - \lambda_1^2}.\quad \frac{dn}{dt} = A_t(10)^{-6}.$$

$10^{-5}\Delta_{t\lambda} = (n_{t''\lambda} - n_{t'\lambda})/(t'' - t')$. $\dfrac{dN}{dp} = A_p(10)^{-6}$; d = density, abs. = strong absorption, met. r. = metallic reflection.

CS$_2$

$t = 18°$, $d = 1.266$; $k = 0.0003$, $a = 2.51516$, $b_1 = 0.041695$, $\beta_1^2 = 0.04731930$, if $0.260 < \lambda < 1.998$ (34); $n_\infty^2 = 2.511$, $M_1 = 0.04736$, $\lambda_1^2 = 0.0334$, limits of λ not indicated (1).

λ		n	A_t
		(17, 18, 34)	(25)
Al	0.2175	met. r.	
Fe	0.260	2.160	
Cd	0.2677	2.110	−1750
Cd	0.2749	2.008	−1500
Cd	0.2881	1.912	
Cd	0.2981	1.875	
Fe	0.304	1.852	
Sn	0.317	1.807	
Fe	0.321	abs.	
Cd	0.3261	1.782*	
Zn	0.335	1.791*	
Cd	0.3610	1.740	− 960

CS$_2$.—(*Continued*)

λ		n	A_t
		(6)	
Al	0.3944	1.704	− 900
Hγ	0.4341	1.6766	− 870
Cd	0.4416	1.673	− 860
Cd	0.4678	1.661	− 840
Cd	0.4800	1.656	− 830
Hβ	0.4861	1.6544	− 830
Cd	0.5086	1.647	− 820
Cd	0.5338	1.640	− 810
(D)	0.5893	1.6295	− 800
Hα	0.6563	1.6201	− 780
		(49)	
	0.8	1.607	
	1.0	1.598	
	1.5	1.588	
	2.0	1.585	
	5.8	met. r.	

* Anomalous dispersion (CS$_2$) from $\lambda = 0.3261$ to $\lambda = 0.355$.

CS_2.—(*Continued*)

λ		t, °C	A_p
			(48)
(*D*)	0.5893	5	+60
(*D*)	0.5893	10	+62
	0.486	15	+67
(*D*)	0.5893	15	+64
	0.686	15	+62
(*D*)	0.5893	20	+66
(*D*)	0.5893	25	+68
(*D*)	0.5893	27.5	+69

	λ		$\Delta_{t\lambda}$
t′, −20°; t″, +40° (26)	*G′*	0.4340	−87.2
	F	0.4861	−83.4
	D	0.5893	−79.4
	C	0.6563	−77.9

C_6H_6, Benzene

$d = 0.880$, $t = 20°C$; $n_\infty^2 = 2.194$, $M_1 = 0.02409$, $\lambda_1^2 = 0.01714$, limits of λ not indicated (1).

λ		n	A_t
		(57)	(69)
	0.1745	met. r.	
Cd	0.2763	1.625	
Cd	0.2837	1.619	
Cd	0.2881	1.612	
Cd	0.2981	1.598	
Cd	0.3081	1.587	
Cd	0.3133	1.582	
Cd	0.3261	1.570	
Cd	0.3404	1.560	
Cd	0.3466	1.556	
Cd	0.3610	1.548	
		(6)	
Hγ	0.4341	1.523	−670
Cd	0.4678	1.516	
Cd	0.4800	1.514	
Hβ	0.4861	1.513	−660
Cd	0.5086	1.509	
(*D*)	0.5893	1.501	−650
Hα	0.6563	1.496	−640
		(49)	
	0.8	1.489	
	1.0	1.485	
	1.5	1.480	
	1.85	1.478	

C_6H_6.—(*Continued*)

For λ = 0.5893 (*D*).

t, °C	A_p(48)
5	+46
10	+47
20	+51
25	+52
27.5	+53

t′ = 12°C; t″ = 30°C.

λ		$\Delta_{t\lambda}$ (69)
G′	0.4340	−67.4
F	0.4861	−66.8
D	0.5893	−64.6
C	0.6563	−64.5

C_8H_{10}, Xylene

Mixture of *o*-, *m*-, and *p*-; $d = 0.866$, $t = 20°C$; $n_\infty^2 = 2.177$, $M_1 = 0.02037$, $\lambda_1^2 = 0.0246$, limits of λ not indicated (1).

λ		n (57)
Cd	0.2981	1.586
Cd	0.3081	1.575
Cd	0.3133	1.570
Cd	0.3261	1.560
Cd	0.3404	1.550
Cd	0.3466	1.546
Cd	0.3610	1.539
		(5)
Hγ	0.4341	1.517
Cd	0.4678	1.509
Cd	0.4800	1.507
Hβ	0.4861	1.507
Cd	0.5086	1.503
(*D*)	0.5893	1.496
Hα	0.6563	1.492
		(49)
	0.8	1.486
	1.0	1.482
	1.5	1.477
	1.88	1.476

TABLE 5.—REFRACTIVITY OF DYES

All dyes in this table are isotropic solids which exhibit selective reflection. *n* is determined either by prism or by reflection, as indicated, and is with reference to air at the same (room) temperature. Designations of Fraunhofer lines are in italics; *e.g.* (*D*).

Fuchsin, $C_{20}H_{20}ClN_3$

λ		n
Prism (42, 44)		
	0.344	1.60
	0.360	1.52
	0.399	1.24
	0.405	1.38
Hδ	0.410	1.17
	0.413	1.15

Fuchsin.—(*Cont'd*)

λ		n
Prism (42, 44)		
Hγ	0.434	1.04
Sr	0.461	0.83
Hβ	0.486	1.05
Tl	0.535	1.95
(*D*)	0.589	2.64
Li	0.671	2.34
	0.703	2.30

Fuchsin.—(*Cont'd*)

λ		n
Reflection (68)		
(*H*)	0.397	1.32
	0.425	1.00
(*G*)	0.431	0.95
	0.455	0.847
Hβ	0.486	1.074
(*E*)	0.527	1.912
(*D*)	0.589	2.684
	0.634	2.412

Fuchsin.—(*Cont'd*)

λ		n
Reflection (68)		
Hα	0.656	2.310
(*B*)	0.687	2.161
(*a*)	0.719	2.086
	0.760	2.019

Malachite green, $C_{23}H_{25}ClN_2$

λ		n
Prism (42)		
Hδ	0.410	1.28
	0.416	1.37
Hγ	0.434	1.38
Hβ	0.486	1.45
Tl	0.535	1.16
(*D*)	0.589	1.33
Li	0.671	2.50
	0.703	2.49

Hofmann violet, $C_{26}H_{32}ClN_3$

λ		n
Prism (42, 66)		
	0.376	1.58
	0.403	1.47
	0.423	1.45
Hγ	0.434	1.32
	0.445	1.23
Hβ	0.486	0.86
Tl	0.535	1.27
(*D*)	0.589	2.20
	0.650	2.42
Li	0.671	2.53
	0.703	2.57

Diamond green $C_{27}H_{18}N_4O_8S$

λ		n
Prism (43)		
(*G*)	0.431	1.48
	0.475	1.70
Hβ	0.486	1.60

Diamond green.—(*Cont'd*)

λ		n
Prism (43)		
	0.517	1.41
(*E*)	0.527	1.31
	0.553	1.09
(*D*)	0.589	1.27
Hα	0.656	2.01
(*a*)	0.719	2.42
Reflection (68)		
(*G*)	0.431	1.46
	0.475	1.54
Hβ	0.486	1.44
	0.517	1.24
(*E*)	0.527	1.14
	0.553	1.03
(*D*)	0.589	1.27
Hα	0.656	2.15
(*a*)	0.719	2.41

Cyanin, $C_{29}H_{35}IN_2.1.5H_2O$

λ		n
Prism (42, 43)		
	0.288	1.71
	0.350	1.70
	0.378	1.69
	0.407	1.68
Hγ	0.434	1.61
(*e*)	0.438	1.59
Sr	0.461	1.49
Hβ	0.486	1.43
	0.505	1.28
	0.520	1.19
Tl	0.535	1.20
	0.540	1.25
	0.565	1.39
(*D*)	0.589	1.71
	0.620	1.94

Cyanin.—(*Cont'd*)

λ		n
Prism (42, 43)		
	0.645	2.23
	0.656	2.19
	0.671	2.11
	0.700	2.03
	0.703	1.98
Prism (71)		
	0.395	1.58
Hδ	0.410	1.57
	0.421	1.55
	0.440	1.52
	0.455	1.47
	0.467	1.42
	0.484	1.35
	0.493	1.29
	0.497	1.25
	0.504	1.17
	0.508	1.12
	0.648	2.35
	0.660	2.25
	0.668	2.19
	0.685	2.12
	0.700	2.06
	0.723	2.02
(*A*)	0.745	1.97
	0.765	1.93

Magdala red, $C_{30}H_{20}N_4.HCl$

λ		n
Prism (42)		
Hδ	0.410	1.76
Hγ	0.434	1.72
Hβ	0.486	1.54
Tl	0.535	1.56
D	0.589	1.90
Li	0.671	2.06
	0.703	2.06

LITERATURE

(For a key to the periodicals see end of volume)

(1) Becquerel, *B85*, p. 531. (1.1) Bedson and Williams, *25*, **14**: 2549; 81. (2) Borel, *34*, **120**: 1404; 95. (3) Borel, *149*, **34**: 134; 95. (4) Brühl, *13*, **203**: 1; 80. (5) Brühl, *13*, **235**: 1; 86. *52*, **50**: 119; 94. (6) Brühl, *7*, **22**: 373; 97. (7) Bugarsky, *7*, **71**: 705; 10. (8) Carvallo, *B85*, p. 461. (9) Chéneveau, *6*, **12**: 145, 289; 07.

(10) Crombez, *186*, **1919**: 875. (11) Damien, *Ann. école norm.*, **10**: 233; 81. (12) Duclaux and Jeantet, *51*, **2**: 346; 22. (13) Dufet, *191*, **8**: 171; 85. (14) Dussaud, *149*, **27**: 521; 92. (15) Eisenlohr, *7*, **75**: 585; 10. (16) Eykman, *70*, **12**: 268; 93. (17) Flatow, *8*, **12**: 85; 03. (18) Fricke, *8*, **16**: 865; 05. (19) Gifford, *5*, **70**: 329; 02.

(20) Gladstone and Dale, *62*, **153**: 317; 63. (21) Grailich, *Krystallographisch-Optische Untersuchungen*, p. 76. Vienna, 1858. (22) Haagen, *8*, **121**: 117; 67. (23) Homfray, *4*, **87**: 1430; 05. (24) Hubbard, *7*, **74**: 207; 10. (25) Ketteler, *8*, **33**: 506; 88. (26) Ketteler, *8*, **35**: 662; 88. (27) Korten, *Diss.*, Bonn, 1890. (28) Landolt, *8*, **117**: 352; 62. (29) Landolt, *8*, **122**: 545; 64.

(30) Landolt and Jahn, *7*, **10**: 289; 92. (31) Langley, *Ann. Ast. Obs. Smithsonian Inst.*, **1**: 1; 00. (32) Lenz, *91*, **19**: 297; 80. (33) Lorenz, *8*, **11**: 70; 80. (34) Martens, *8*, **6**: 603; 01. (35) Martens, *8*, **8**: 459; 02. (36) Micheli, *8*, **7**: 772; 02. (37) Nasini and Bernheimer, *36*, **15**: 59; 85. (38) Oudemans, *70*, **4**: 269; 85. (39) Paschen, *8*, **4**: 299; 01.

(40) Paschen, *8*, **26**: 120; 08. (41) Perkin, *4*, **61**: 287; 92. (42) Pflüger, *8*, **56**: 412; 95. (43) Pflüger, *8*, **58**: 670; 96. (44) Pflüger, *8*, **65**: 173; 98. (45) Pulfrich, *8*, **34**: 326; 88. (46) Quincke, *8*, **44**: 774; 91. (47) Richards and Schumb, *1*, **40**: 1403; 18. (48) Röntgen and Zehnder, *8*, **44**: 24: 91. (49) Rubens, *8*, **45**: 238; 92.

(50) Rubens, *76*, **38**: 556; 17. (51) Rubens and Hollnagel, *26*, **12**: 83; 10. (52) Rubens and Snow, *8*, **46**: 529; 92. (53) Rubens and Trowbridge, *8*, **60**: 724; 97. (54) Rudolphi, *7*, **37**: 426; 01. (55) Sarasin, *149*, **10**: 303; 83.

(56) Sella, *22*, **7 II**: 300; 91. (57) Simon, *8*, **53**: 542; 94. (58) Soret, *149*, **12**: 553; 84. (59) Soret, *149*, **13**: 5; 85.
(60) Soret and Sarasin, *34*, **108**: 1248; 89. (61) Stefan, *75*, **63 II**: 223; 71. (62) Tear, *143*, **194**: 685; 22. (63) Timmermans and Martin, Univ. Brussels, *0*.
(64) Topsöe and Christiansen, *6*, **1**: 5; 74. (65) Verschaffelt, *186*, **27**: 69; 94. (66) Verschaffelt and Crombez, *186*, **2**: 31; 20. (67) Walter, *8*, **42**: 505; 91. (68) Walter, *Die Oberflächen- oder Schillerfarben*. Braunschweig, Vieweg, 1895. (69) Weegmann, *7*, **2**: 218; 88.
(70) Wernicke, *8*, **142**: 560; 71. (71) Wood, *3*, **46**: 380; 98. (72) Zehnder, *8*, **34**: 91; 88.

REFRACTIVITY OF BIREFRINGENT CRYSTALS

H. E. Merwin

These tables have to do primarily with variations of refractive index with wave-length and temperature. For refractive indices at a single wave-length, for $2V$ or $2E$, for orientations, etc., *see* Vol. I, p. 166, 279, 320; and (**56, 81.1, 115, 116.1, 235.1**). For dispersion of birefringence, *see* (**59–62**); for refractivity of metallic crystals, *see* Vol. V, p. 248; for isotropic substances, *see* Vol. I, p. 165 (*cf.* p. 106), Vol. VII, p. 12, and for elementary substances, *see* Vol. VII, p. 1.

Ces tables concernent principalement les variations de l'indice de réfraction avec la longueur d'onde et avec la température. Pour les indices de réfraction concernant une seule longueur d'onde, pour $2V$ ou $2E$, pour les orientations, etc., *voir* Vol. I, p. 166, 279, 320; et (**56, 81.1, 115, 116.1, 235.1**). Pour la dispersion de la biréfringence, *voir* (**59–62**); pour le pouvoir réfractif des cristaux métalliques, *voir* Vol. V, p. 248; pour les substances isotropiques, *voir* Vol. I, p. 165 (*cf.* p. 106), Vol. VII, p. 12, et pour les éléments, *voir* Vol. VII, p. 1.

Diese Tafeln behandeln vor allem die Änderung des Brechungsindexes mit der Wellenlänge und der Temperatur. Für die Brechungsindexes einzelner Wellenlängen, für $2V$ oder $2E$, Orientierung, etc., *siehe* Bd. I, S. 166, 279, 320; ferner (**56, 81.1, 115, 116.1, 235.1**). Für die Dispersion der Doppelbrechung, *siehe* (**59–62**); für das Brechungsvermögen von Metallkristallen, *siehe* Bd. V, S. 248; für isotropischen Stoffe, *siehe* Bd. I, S. 165 (*cf.* S. 106), Bd. VII, S. 12, und für Elemente, *siehe* Bd. VII, p. 1.

Queste tabelle si riferiscono principalmente alle variazioni dell'indice di birifrangenza in funzione della lunghezza d'onda e della temperatura. Per gli indici di rifrazione ad una sola lunghezza d'onda, per $2V$ e $2E$, per le orientazioni, ecc., *vedi* Vol. I, p. 166, 279, 320; e (**58, 81.1, 115, 116.1, 235.1**). Per la dispersione della birifrangenza, *vedi* (**59–62**); per la refrattività dei cristalli metallici, *vedi* Vol. V, p. 248; per le sostanze isotropiche, *vedi* Vol. I, p. 165 (*cf.* p. 106), Vol. VII, p. 12, e per le elementi, *vedi* Vol. VII, p. 1.

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LIST OF BIREFRACTING MINERALS IN TABLE 1

Those for which the dispersion of the index has been most accurately and extensively measured are indicated by a "(*d*)."

Name	Serial No., Table 1	Name	Serial No., Table 1
Acmite	209	Avogadrite	260.1
Adularia	261	Barite	(*d*)182
Afwillite	147	Barylite	187.1
Åkermanite	170	Beckelite	165
Albite	(*d*)218	Beryl	(*d*)120
Allactite	61	Beryllonite	222
Anatase	(*d*)14	Blödite	224
Andalusite	101	Boracite	134
Andesine	229	Borax	215
Anglesite	(*d*)19	Borgströmite	73
Anhydrite	137.1	Boussingaultite	123
Anorthite	159	Brookite	15
Apatite	(*d*)140	Brucite	121
Apophyllite	(*d*)267	Calamine	39
Aragonite	(*d*)141	Calcite	(*d*)142
Augite	169	Calomel	46

LIST.—(*Continued*)

Name	Serial No., Table 1	Name	Serial No., Table 1
Cancrinite	228	Diamond*	11.1
Carborundum	(*d*)13	Diopside	(*d*)169
Cassiterite	18	Dioptase	52
Celestite	173	Dolomite	(*d*)168
Cerussite	25	Elpidite	207
Chalcanthite	49	Epididymite	223
Chrysoberyl	118	Epidote	161
Chrysolite	(*d*)131	Epsomite	(*d*)122
Cinnabar	48	Euclase	119
Clinozoisite	161	Eudialite	227
Colemanite	157	Feldspars	261
Copiapite	72	Finnemanite	23
Cordierite	(*d*)136	Forsterite	(*d*)126
Corundum	(*d*)97	Goethite	63
Cotunnite	18.1	Goslarite	32
Cyanite	99	Greenockite	42
Cyanochroite	249	Gypsum	(*d*)138
Danburite	158		

LIST.—(*Continued*)

Name	Serial No., Table 1	Name	Serial No., Table 1
Hambergite	(*d*)117 1	Orthoclase	(*d*)261
Hardystonite	150	Parisite	164
Hedenbergite	153	Penninite	135
Hematite	62	Phenacite	116
Hemimorphite	39	Phosgenite	27
Hornblende	166	Picromerite	264
Hussakite	113	Pirssonite	226
Hutchinsonite	57	Proustite	56
Ice	(*d*)1	Pyromorphite	22
Iceland spar	142	Pyroxene	169
Iodyrite	54	Quartz	(*d*)12
Klinozoisite	161	Realgar	9
Laboradorite	229	Rhomboclase	71
Lepidocrocite	64	Rinneite	271
Leucite	262	Rutile	16
Leucosphenite	231	Scapolite	162
Lorenzenite	207.1	Scheelite	156
Marialite	221	Siderite	76
Mascagnite	(*d*)5	Sillimanite	100
Meionite	162	Smithsonite	36
Melanterite	64.1	Soda niter	(*d*)191.1
Melilite	170	Sphalerite*	31.1
Mellite	98	Sphene	148
Mesolite	230	Spodumene	190
Mica	263	Saurolite	(*d*)103
Microcline	261.1	Sttibiotantalite	96
Mimetite	24	Stibnite	11
Moissanite	13	Sulfur	2
Molybdenite	92	Swedenborgite	216
Molybdophyllite	129	Syngenite	266
Monazite	106	Titanite	148
Monticellite	(*d*)154	Topaz	(*d*)102
Morenosite	85	Tourmaline	(*d*)225
Muscovite	263	Tremolite	171
Narsarsukite	210	Trimerite	117
Natrolite	220	Vanadinite	95
Nephelite	217	Whewellite	143
Niter	(*d*)236	Willemite	(*d*)38
Nocerine	167	Wulfenite	93
Oligoclase	229	Zincite	(*d*)31
Olivine	(*d*)126	Zircon	(*d*)17

* Isotropic; for comparison only.

Accurate Dispersions.—The birefracting crystals for which the most accurate and extensive measurements of the dispersion of the refractive index have been made are these, and those which are marked "(*d*)" in the preceding list.

	No.		No.
Ammonium oxalate ($C_2H_8N_2O_4$)		KIO_4	231.2
		K_2SO_4	232
Rhamnose ($C_6H_{12}O_5.H_2O$)		$K_2S_2O_6$	233
Saccharose ($C_{12}H_{22}O_{11}$)		$Mg(NH_4)_2(SeO_4)_2.6H_2O$	124
$Co(NH_4)_2(SO_4)_2.6H_2O$	81	$(NH_4)_2SO_4$	5
$Cs_2S_2O_6$	293	$NaNO_3$ (ω)	191.1
$CuSO_4.5H_2O$	49	$Ni(NH_4)_2(SO_4)_2.6H_2O$	87
$K_2Co(SO_4)_2.6H_2O$	255	$SrS_2O_6.4H_2O$	174
KNO_3	236	ZnO	31
$KClO_4$	231.1		

The measurements for quartz (12), epsomite (122), and calcite (142) extend into the ultra-violet; and those for quartz and calcite into the infra-red also. (Numbers refer to Table 1.)

TABLE 1.—REFRACTION OF BIREFRINGENT CRYSTALS

See also Figs. 1 and 2

Standard arrangement (Vol. III, p. viii); substances containing C but no element of key-number greater than 16 are given in section II (p. 29). For more exact wave-lengths corresponding to symbols in the λ-column, *see* Table 3; alphabetical list of minerals, p. 16.

Definitions.—$10^{-4}\delta\omega_D = \omega_\lambda - \omega_D$, etc.; $10^{-5}\tau_\omega = d\omega/dt$, etc.; also $10^{-5}\tau_\omega = (\omega_{t''} - \omega_{t'})/(t'' - t')$, etc., if observations have been made at only two temperatures. The two classes of τ are not distinguished; both are reduced to vacuum (*see* Table 4). For uniaxial crystals, ω = index of refraction for ordinary ray, ϵ = that for extraordinary ray; if $\omega < \epsilon$, the crystal is optically positive. For biaxial crystals, α, β, γ = principal indices of refraction, $\alpha < \beta < \gamma$. All indices of refraction are referred to air at the temperature of the crystal, usually room temperatures, except when expressed with τ thus: τ_ω, etc. $2V$ = interior optic axial angle; $\tan^2 V = \left[\dfrac{\frac{1}{\alpha^2} - \frac{1}{\beta^2}}{\frac{1}{\beta^2} - \frac{1}{\gamma^2}}\right]^{\pm 1}$, the sign of the exponent being so chosen as to make $\tan^2 V < 1$; if this sign is +, then the crystal and V are positive, in the contrary case they are negative. For rapid computation of V, *see* Wright's tables (236.2).

Range of Variation.—The observed range is indicated in one of the following ways, *e.g.*: $\omega_D = 2.534$ to 2.564, $\omega_D = 2.534(64)$, $\omega_D = \left\{\begin{matrix}2.534\\2.564\end{matrix}\right.$.

Accuracy.—If final figure is probably inaccurate by 2 to 5 units, it is printed in small type. Tabulated dispersions (δ) probably do not depart from a smooth curve by more than 1.5 units in final figure unless that is printed in small type.

Data.—Observers have often placed more stress upon variations for a particular specimen than upon actual values and the purity of the material. Data for materials probably pure are indicated by *P*, those nearly pure by *p*. Unit of λ = 10 Å = 1mμ = 10^{-7} cm. Temperature = *t*, °C.

I. 𝔄-𝔅-Table: Inorganic Substances; Standard Arrangement; *v.* Vol. III, p. viii

1. H_2O, Ice (59) *P*; *cf.* Fig. 1

λ	
589*D*	$\omega = 1.3090$, $\epsilon = 1.3104$, $t = -3°$
λ	$\delta\omega_D$
405Hg	93
436Hg	69
486*F*	39
492Hg	36+
546Hg	14
578Hg	3+
623Hg	−11
656*C*	−19+
691Hg	−27
706He	−30

$t = -3°$ and $-65°$; $\delta\epsilon_D = 1.01\delta\omega_D$; $\tau_\omega = \tau_\epsilon = -3.8$.

2. S* (Rhombic form) (14, 60, 176, 179); *P*; *cf.* Fig. 1

λ	α	β	γ
434*G′*	2.042	2.139	2.3914
436Hg	2.040	2.137	2.3878
447He	2.029	2.123	2.3682
468Cd	2.012	2.103	2.3384

2.—(*Continued*)

λ	α	β	γ
471He	2.010	2.101	2.3340
480Cd	2.004	2.093	2.3239
486*F*	1.999	2.087	2.3172
492He	1.996	2.084	2.3111
502He	1.991	2.077+	2.3021
508Cd	1.987	2.073	2.2959
535Tl	1.976	2.058	2.2757
561Pb	1.967	2.049	2.2600
588He	1.958	2.038	2.2463
589*D*	1.957	2.037+	2.2454
644Cd	1.944	2.023	2.2243
656*C*	1.942	2.019+	2.2203
668He	1.940	2.017+	2.2168
671Li	1.939+	2.017	2.2159
768*A′*	1.926	2.001	2.1936

For $8° < t < 30°$ and λ = 535Tl, $\tau_\alpha = -17$, $\tau_\beta = -23$, $\tau_\gamma = -28$; for λ = 671Li, $\tau_\alpha = -17$, $\tau_\beta = -21+$, $\tau_\gamma = -25+$ (179). $+2V_D = 69°$ (41, 179); $(2V_F - 2V_C) < \pm 0.5°$ (133).

* Data read from curves.

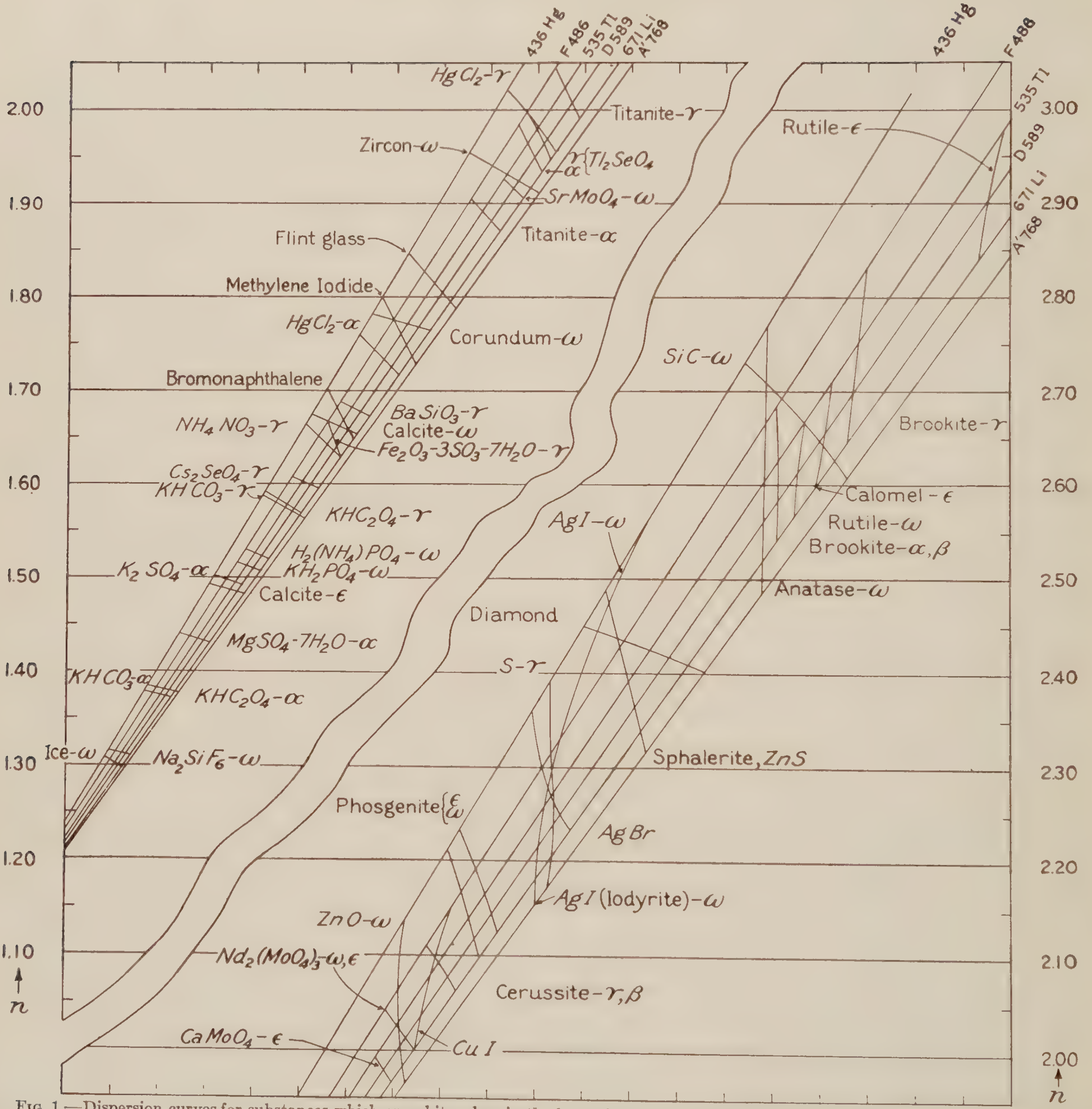

FIG. 1.—Dispersion curves for substances which are white when in the form of a fine dry powder. The lines of constant wave-length form a pencil diverging from $n = 1$; the values of λ corresponding to the six lines drawn are marked at their upper ends. With few exceptions, the curve for any substance covers the entire range of λ over which the index has been determined. A few isotropic substances are included for comparison.

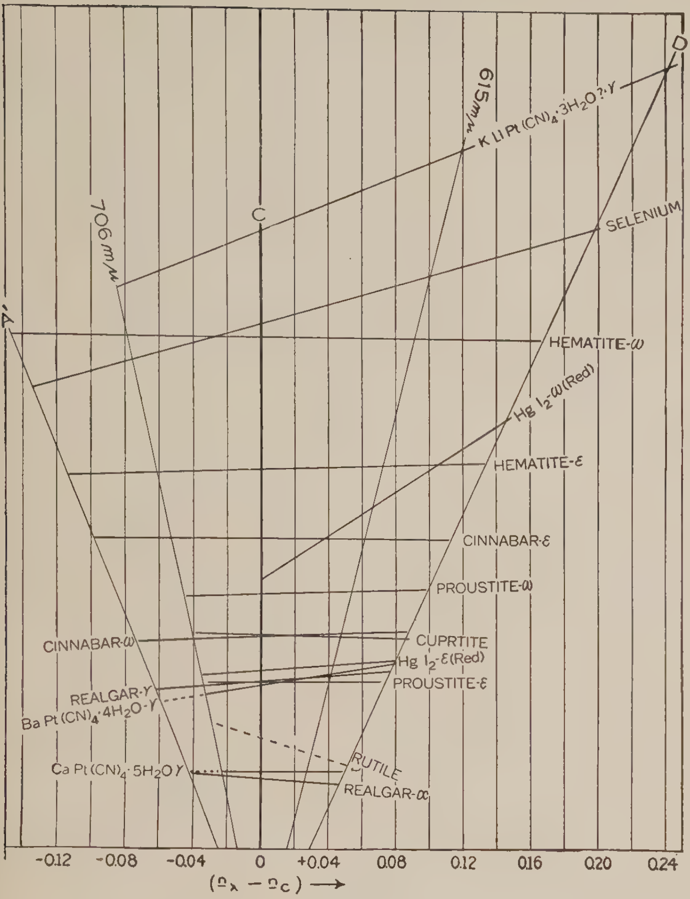

FIG. 2.—Dispersion curves for substances (rutile ε excepted) which are red, orange, or yellow when in the form of a fine dry powder. The lines (A′ to D) of constant wave-length form a pencil diverging from a point on the line C, the abscissae are the values of the difference (Index_λ − Index_C), where λ = A′, D, etc. Selenium is glassy, and cuprite (cuprtite in cut) is isotropic.

3. Se, (Hexagonal form) *P*

By transmission, $\omega_{680m\mu} = 3.0$, $(\epsilon - \omega)_{680m\mu} = 0.1_7$ (**133**)

By reflection (**134.1, 184.1, 186**)

λ	n_1*	n_2*
300	$3._3$	2.3
400	$3._9$	3.0
500	$4._1$	3.1
600	$4._1$	3.1
700	$4._0$	3.1

* Plane of incidence and electric vector ‖ principal axis of crystal for n_1, ⊥ for n_2. By comparison with transmission data, $n_2 = \omega$, $n_1 = \epsilon$(?).

3.1. Te, (Hexagonal form) (**134.1, 222.1**); *P*

λ	n_1*	n_2*
300	1.9	1.5
400	2.7	2.4
500	3.0	2.6
600	3.0	2.5
650	2.6	2.1

* Electric vector ‖ optic axis for n_1, ⊥ for n_2. By comparison with Se, $n_2 = \omega$, $n_1 = \epsilon$(?).

3.2. NH_4ClO_4 (**252**); *P*

λ	α	β	γ
589*D*	1.481_8	1.483_3	1.488_1

λ	$\delta_{\beta D}$*	λ	$\delta_{\beta D}$*
434*G′*	86	656*C*	−20

$\delta\alpha_D = 0.98\,\delta\beta_D$; $\delta\gamma_D = 1.03 \times \delta\beta_D$; $2V_C = 69°\ 34'$; $2V_F = 70°\ 4_5'$.

* Curves, *see* 231.1.

4. NH_4NO_3 (**133**) *P*; *cf.* Fig. 1

λ	α	β	γ
405Hg			1.676_6
447He	1.4194	1.634+	1.6621
502He	1.4163+	1.623	1.6494
588He	1.4130	1.611+	1.6370
668He	1.4110+	1.605	1.6296

5. $(NH_4)_2SO_4$, Mascagnite (**208**), δ (**133**); *P*

λ	α	β	γ
589*D*	1.520_9	1.523_0	1.533_0

λ	$\delta\alpha_D$	λ	$\delta\alpha_D$
405Hg	138+	546Hg	21+
434*G′*	105	656*C*	−25
486*F*	59+	706He	−40+

$\delta\beta_D = 1.01\,\delta\alpha_D$; $\delta\gamma_D = 1.05 \times \delta\alpha_D$; $+2V_D = 52°$.

5.—(*Continued*)

For 15° < *t* < 80°, $\tau_\alpha = -4._9$, $\tau_\beta = -4._0$, $\tau_\gamma = -6._2$; all colors.

6. $(NH_4)_3H(SO_4)_2$ (**68**); *P*

λ	α	β	γ
535Tl	1.504	1.509	1.535
589*D*	1.496	1.502	1.528
671Li	1.491	1.496	1.523

7. $(NH_4)_2SeO_4$ (**210**); *P*

λ	α	β	γ
589*D*	1.560 1.561+	1.562 1.563+	1.584 1.585+
486*F*	1.5687	1.5713	1.5935
589*D*	1.5607	1.5630	1.5846
656*C*	1.5571	1.5594	1.5806

For 80° < *t* < 100°, $\tau_\alpha = -1$, $\tau_\beta = -3+$, $\tau_\gamma = -4+$; all colors.

8. $(NH_4)H_2PO_4$ (**200**); *p*; *see* Fig. 1

λ	ω	ε
486*F*	1.531_4	1.484_7
589*D*	1.524_6	1.479_2
656*C*	1.521_2	1.476_8

9. AsS, Realgar (**230**); *see* Fig. 2

λ	α	β	γ
545	2.584		
555	2.574		
570	2.558		2.741
575		2.707	2.728
590	2.538	2.684	2.704
610	2.521	2.656	2.675
640	2.502	2.626	2.643
680	2.482	2.594	2.613
710	2.468	2.575	2.594
740	2.458	2.560	2.578
750	2.456	2.556	

$-2V_{648} = 49.5°$.

10. $(NH_4)H_2AsO_4$ (**200**); *p*

λ	ω	ε
486*F*	1.585_9	1.529_6
589*D*	1.576_6	1.521_7
656*C*	1.572_1	1.518_6

11. Sb_2S_3, Stibnite (**221**)

λ		n_2	n_1
435		4.4	4.6
460		4.5	5.1
500		4.7	5.5
540		4.6	5.4
620		4.5	4.9
680		4.7	4.7
λ	α	β	γ
761	3.194*	4.046*	4.303*
823		3.919*	4.193*

* From (**95**).

11.1. C, Diamond;* *see* Fig. 1; for other carbon compounds, *see* p. 29

* Isotropic; included for comparison only.

12. SiO_2, Quartz; *P*; *see* Vol. VI, p. 341

13. SiC, Carborundum,* moissanite (**229**); *cf.* Fig. 1

λ	ω	ε
434*G′*	2.7313	2.7877
436Hg	2.7297	2.7859
455Ba	2.7138	2.7677
486*F*	2.6931	2.7442
492He	2.6894	2.7401
502He	2.6842	2.7342
546Hg	2.6632	2.7106
578Hg	2.6513	2.6974
588He	2.6481	2.6939
589*D*	2.6476	2.6933
656*C*	2.6296	2.6734
668He	2.6271	2.6707
706He	2.6195	2.6623
768*A′*	2.6098	2.6516

$\omega^2 = 0.83921 + 5.7099\lambda^2/(\lambda^2 - 161^2)$, unit of λ = 1mμ = 10 Å.

t	20° 460°	460° 760°	760° 1150°
λ		τ_ω	
471	7.5_0	10.0	
554	6.6_6	8.2_1	9.7_3
650	6.1_5	7.6_0	9.0_0
668	5.9_2	7.4_2	
λ		τ_ϵ	
471	8.2_0	11.5+	
668	6.3_6	8.0_8	

* Contains 0.77 % Fe; values for *A′*, *C*, *D*, *F* and *G′* are by interpolation. Values of ω were computed by the equation given. For another specimen (**126**) ω and ε were about 0.006 greater.

14. TiO_2 *ca.*, **Anatase** (**59**); *cf.* (**14, 196, 237**); *cf.* Fig. 1

λ	ω	ε
405Hg	2.8760	2.7395
436Hg	2.7688	2.6576
492Hg	2.6586	2.5691
546Hg	2.5955	2.5169
578Hg	2.5694	2.4950
589*D*	2.534(64)*	2.488(97)*
623Hg	2.5407	2.4709
691Hg	2.5106†	2.4456†
706He	2.5052†	2.4409†

t	25° 300°	300° 450°	450° 750°
λ		τ_ω	
436	$-1._8$		
492	$-2._4$	$-1._1$	
546	$-2._5$	$-1._4$	$-0._6$
607	$-2._4$	$-1._9$	$-1._1$
691	$-2._6$	$-2._0$	$-1._3$
λ		τ_ϵ	
436	$+0._4$		
492	$-0._6$	$+0._6$	
546	$-0._8$	$-0._1$	$+0._6$
607	$-1._3$	$-0._4$	$0._0$
691	$-0._8$	$-1._1$	$0._0$

* From (**14, 102, 178**).

† Interpolated.

15. TiO_2 *ca.*, Brookite (196, 237, 250); *cf.* Fig. 1

λ	α	β	γ
436Hg	2.769	2.784	2.941
486*F*	2.680	2.685	2.820
535Tl	2.624	2.626	2.752
589*D*	2.583	2.584	2.700
656*C*	2.547	2.551	2.660
671Li	2.541	2.545	2.653

t	25° 300°	300° 600°	
λ	τ_b		
436	5.3		τ_β
492	3.0	3.0	
546	2.1	2.1	τ_α
579	1.9	1.9	
671	1.4	1.1	
708	1.3	0.9	
λ	τ_a		
436	5.1		τ_α
492	3.7	3.7	
546	2.4	2.4	τ_β
579	2.4	2.4	
671	2.0	1.8	
708	1.7	1.5	
λ	$\tau_c = \tau_\gamma$		
492	−8.4		
546	−9.1	−5.1	
579	−8.9	−5.3	
671	−8.9	−5.0	

16. TiO_2 *ca.*, Rutile (9); *cf.* Fig. 1 and Fig. 2. for ε

λ	ω	ε
535Tl	2.6725	2.9817
589*D*	2.6158	2.9029
671Li	2.5671	2.8415

t	25° 300°	300° 450°	450° 600°
λ	τ_ω		
546	−5.1	−2.7	
579	−5.0	−3.1	−1.4
623	−4.6	−3.1	−2.0
691	−4.5	−3.0	
λ	τ_ϵ		
546	−8.9		
579	−7.7	−5.3	−4.8
623	−7.7	−5.4	

Range (9, 98, 162, 196); ω_D = 2.60+ to 2.61+; ϵ_D = 2.89 to 2.90+; $(\epsilon - \omega)_D$ = 0.286 to 0.287; dispersion for ε (98, 196) 10% to 20% less than tabulated.

17. $ZrSiO_4$ *ca.*, Zircon (133); *cf.* (14, 64, 172, 190); *cf.* Fig. 1

λ	ω	ε
405Hg	1.9640	2.0239
434*G′*	1.9540	2.0139
436Hg	1.9535	2.0134
486*F*	1.9411	2.0007
492Hg	1.9401	1.9996
546Hg	1.9309	1.9902
589*D*	1.9254	1.9848
656*C*	1.9192	1.9782
768*A′*	1.9120	1.9708

17.—(*Continued*)

Range for zircon (64); ω_D = 1.878 to 1.931, ϵ_D = 1.895 to 1.993; low values are uncommon. If $25° < t < 1000°$; in blue $\tau_\omega = +2.0$, $\tau_\epsilon = +2.1$; in red $\tau_\omega = +1.6$, $\tau_\epsilon = +1.8$ (64).

18. SnO_2, Cassiterite (14)

λ	ω	ε
447He	2.0437	2.1345
486*F*	2.0260*	2.1193*
502He	2.0204	2.1144
588He	1.9983	2.0944
656*C*	1.9873	2.0842
668He	1.9858	2.0826

* Interpolated.

18.1 $PbCl_2$, Cotunnite (56, 115)

λ	α	β	γ
589*D*	2.199	2.217	2.259
671Li	2.179	2.192	

19. $PbSO_4$, Anglesite (61, 103, 111); *P*

λ	α	β	γ
589*D*	1.877(8)	1.882(3)	1.893(4)

λ	$\delta\beta_D$	λ	$\delta\beta_D$
405Hg	474+	546Hg	165
436Hg	342	656*C*	− 74
486*F*	188+	706He	−116

$\delta\alpha_D = 0.99\delta\beta_D$; $\delta\gamma_D = 1.02\delta\beta_D$. If $-50° < t < +550°$, for λ = 434*G′*, $\tau_\alpha = -2.6$, $\tau_\beta = -2.1+$, $\tau_\gamma = -3.5$; for λ = 687*B*, $\tau_\alpha = -3.0+$, $\tau_\beta = -2.5+$, $\tau_\gamma = -3.9+$.

20. $PbS_2O_6.4H_2O$ (167); *cf.* (17); *P*

λ	ω	ε
405Hg	1.6683	1.6865
436Hg	1.6589	1.6774
492Hg	1.6480	1.6672
546Hg	1.6400	1.6591
579Hg	1.6366	1.6557
623Hg	1.6335	1.6531
691Hg	1.6290	1.6486

21. $Pb_3(PO_4)_2$ (245); *p*

λ	ω	ε
486*F*	1.999	1.962
527*E*	1.985	1.949
589*D*	1.970	1.936
656*C*	1.959	1.926

22. $Pb_5P_3O_{12}Cl$, Pyromorphite (26)

λ	ω	ε
486*F* *ca.*	2.091	2.078
589*D*	2.061	2.049
656*C* *ca.*	2.050	2.042

23. $Pb_5Cl(AsO_3)_3$(?), Finnemanite (4)

λ	ω	ε
486*F*	2.363	2.345
589*D*	2.295	2.285
656*C*	2.272	2.263

24. $Pb_5As_3O_{12}Cl$, Mimetite (26)

λ	ω	ε
486*F* *ca.*	2.186	2.170
589*D*	2.144	2.129
656*C* *ca.*	2.133	2.128

25. $PbCO_3$, Cerussite (43, 144); *cf.* Fig. 1

λ	α	β	γ
589*D*	1.798 1.804	2.073 2.076	2.074 2.078
λ	$\delta\alpha_D$	$\delta\beta_D$	$\delta\gamma_D$
486*F*	230	330	320
513	150	220	210
578	30	40	40
636	−60	−100	−100
656*C*	−80	−130	−130

26. $Pb(CHO_2)_2$ (Formate) (101); *cf.* (154); *P*

λ	α	β	γ
434*G′*	1.828+	1.904(1)	1.938
486*F*	1.811	1.878(80)	1.916
589*D*	1.789+	1.852(4)	1.887
656*C*	1.781+	1.843(1)	1.874+

27. $PbO.CO_2.PbCl_2$, Phosgenite (14); *cf.* Fig. 1

λ	ω	ε
434*G′*	2.212	2.234+
447He	2.199	2.222
486*F*	2.167+	2.192+
502He	2.158	2.183
589*D*	2.118	2.145
656*C*	2.100	2.127+

28. Tl_2SO_4 (211); *P*

λ	α	β	γ
486*F*	1.8859	1.8935	1.9126
535Tl	1.8704	1.8778	1.8964
589*D*	1.8600	1.8671	1.8853
656*C*	1.8509	1.8579	1.8755
671Li	1.8493	1.8563	1.8739

29. Tl_2SeO_4 (211); *P*; *cf.* Fig. 1

λ	α	β	γ
486*F*	1.9840	1.9942	1.9987
535Tl	1.9635	1.9737	1.9782
589*D*	1.9493	1.9592	1.9640
656*C*	1.9355	1.9450	1.9500
671Li	1.9331	1.9426	1.9476

30. $Tl_2C_4H_4O_6$ (Tartrate) (84); *P*

λ	ω	ε
535Tl	1.7763	1.8218
589*D*	1.7677	1.8115
671Li	1:7583	1.8006

30.1. Zn (78.2); *P*

λ	n_1*	n_2*
455	1.00	0.78
486	1.35	1.09
520	1.47	1.32
560	1.92	1.61
589	2.58	2.02
630	2.47	2.27
650	2.47	2.07

* Electric vector ∥ optic axis for n_1, ⊥ for n_2.

31. ZnO, Zincite (133); *P*; *cf.* Fig. 1

λ	ω	ε
434*G′*	2.1395	2.1550
436Hg	2.1358	2.1513
447He	2.1143	2.1302

31.—(*Continued*)

λ	ω	ε
471He	2.0806	2.0971
486*F*	2.0649	2.0814
492He	2.0593	2.0759
502He	2.0515	2.0681
546Hg	2.0228	2.0394
589*D*	2.0041	2.0203
656*C*	1.9843	2.0003
668He	1.9817	1.9977
706He	1.9740	1.9898
768*A′*	1.9648	1.9806

31.1. ZnS, Sphalerite;* *P*; *see* Fig. 1

* Isotropic; for comparison only.

32. $ZnSO_4.7H_2O$, Goslarite (43.2, 200); *P*

λ	α	β	γ
486*F*	1.4620	1.4860	1.4905
589*D*	1.4568	1.4801	1.4844
656*C*	1.4544	1.4776	1.4820

33. $ZnSeO_4.6H_2O$ (200)

λ	ω	ε
486*F*	1.5367	1.5108
589*D*	1.5291	1.5039
656*C*	1.5255	1.5004

34. $Zn(NH_4)_2(SO_4)_2.6H_2O$; *see* Table 2

35. $Zn(NH_4)_2(SeO_4)_2.6H_2O$; *see* Table 2

36. $ZnCO_3$, Smithsonite* (137); *P*

λ	ω	ε
431*G*	1.8736	1.6326
486*F*	1.8621	1.6275
535Tl	1.8546	1.6241
589*D*	1.8485	1.6214
656*C*	1.8433	1.6190

* Sample 97.3 % pure $ZnCO_3$.

37. $C_9H_{20}ON_2.2HCl.ZnCl_2.3H_2O$ (163)

Triacetonediamine dihydrochloride zinc chloride trihydrate

λ	α	β	γ
535Tl	1.570	1.574	1.603
589*D*	1.566	1.569	1.594
671Li	1.563	1.565	1.586

38. Zn_2SiO_4, Willemite (61)

589*D*; ω = 1.6893; ε = 1.7179

λ	$\delta\omega_D$	λ	$\delta\omega_D$
405Hg	276	656*C*	−46
436Hg	199	706He	−73
486*F*	110	$\delta\epsilon_D = 1.04\delta\omega_D$	
546Hg	38		

39. $Zn_2H_2SiO_5$, Hemimorphite (calamine) (147)

If $-185° < t < +13°$, $\tau\alpha_D = +0.0$, $\tau\beta_D = +1.3$, $\tau\gamma_D = -0.2$. For birefringence and dispersion of 2*V*, *see* (184).

40. $ZnSiF_6.6H_2O$ (200)

λ	ω	ϵ
486*F*	1.386_0	1.399_2
589*D*	1.382_4	1.395_6
656*C*	1.380_8	1.393_8

41. $Tl_2Zn(SO_4)_2.6H_2O$; *see* Table 2

41.1. $Tl_2Zn(SeO_4)_2.6H_2O$; *see* Table 2

42. CdS, Greenockite (124); *P*

λ	ω	ϵ
523	2.61	2.61
589*D*	2.50_6	2.52_9
671Li	2.43_1	2.45_6
700	2.41_1	2.43_6

43. $2NH_4Cl.CdCl_2$ (177)

λ	ω	ϵ
527*E ca.*	1.611_1	1.611_4
589*D*	1.603_8	1.604_2
687*B ca.*	1.595_8	1.596_1

44. $Cd(NH_4)_2(SO_4)_2.6H_2O$; *see* Table 2

45. $Cd(NH_4)_2(SeO_4)_2.6H_2O$; *see* Table 2

46. $HgCl$, Calomel (49); *P*; *cf.* Fig. 1

λ	ω	ϵ
535Tl	1.9908	2.7129
589*D*	1.9732	2.6559
671Li	1.9556	2.6006

47. $HgCl_2$ (133); *P*; *cf.* Fig. 1

λ	α	β	γ
589*D*	1.72_5	1.859_0	1.96_5

λ	$\delta\beta_D$	λ	$\delta\beta_D$
434*G′*	44_3	656*C*	-9_2
486*F*	23_4		

$\delta\alpha_D = 0.80\,\delta\beta_D$; $\delta\gamma_D = 1.20 \times \delta\beta_D$.

47.1. HgI_2 (Red form) (133); *see* Fig. 2

λ	ω	ϵ
578		2.47_5
589*D*	2.74_8	2.45_5
593	2.73_2	
600	2.71_1	2.43_8
620	2.65_6	2.41_1
656*C*	2.60_0	2.37_5
671Li	2.58_2	2.36_3

48. HgS, Cinnabar (169); *cf.* (60); *p*; *see* Fig. 2

λ	ω	ϵ
589.3*D*		3.275
599.0	2.903	3.256
607.5	2.887	3.238
623.9	2.865	3.209
643.9	2.842	3.178
672.0	2.816	3.143
707.7	2.789	3.107
762.1	2.760	3.068

48.—(*Continued*)

Range of *t*	−110° to −50°	−50° to +12°	12° to 77°	77° to 142°	142° to 200°
λ	τ_ω				
599		13			
607		9			
613		8	13		
624		8	12	15	
636	5	5	9	15	
644	8	5	7	14	17
656		3	6	13	14
718		2	2	7	9
λ	τ_ϵ				
577	30				
589	19	20			
607	21	16	31		
613	20	14	24		
624	17	14	19	27	
636		11	17	24	
644	14	11	15	22	31
656		9	14	22	25
691		7	9	18	18
718		8	8	15	14

48.1. CuI;* *see* Fig. 1

* Isotropic; for comparison only.

49. $CuSO_4.5H_2O$, Chalcanthite (81.1, 133); *P*

λ	α	β	γ
589*D*	1.5141	1.5368	1.5434

λ	$\delta\beta_D$	λ	$\delta\beta_D$
405Hg	167	656*C*	−31
434*G′*	125	671Li	−37
486*F*	70+	687*B*	−43+
535Tl	32		

$\delta\alpha_D = 0.92\delta\beta_D$; $\delta\gamma_D = 1.04 \times \delta\beta_D$.

50. $Cu(NH_4)_2(SO_4)_2.6H_2O$; *see* Table 2

51. $Cu(NH_4)_2(SeO_4)_2.6H_2O$; *see* Table 2

52. $CuSiO_3.H_2O$, Dioptase (98, 159); *cf.* (60)

λ	ω	ϵ
431*G*	1.683	1.742
486*F*	1.669_7	1.724_3
527*E*	1.662_9	1.716_0
589*D*	1.658_0	1.709_7

53. $CuF_6Si.6H_2O$ (200)

λ	ω	ϵ
486*F*	1.413_8	1.412_4
589*D*	1.409_2	1.408_0
656*C*	1.407_4	1.406_2

53.1. $CuTl_2(SO_4)_2.6H_2O$; *see* Table 2

53.2. $CuTl_2(SeO_4)_2.6H_2O$; *see* Table 2

53.3. $AgBr$; *see* Fig. 1

54. AgI, Iodyrite, hexagonal (133); *P*; *cf.* Fig. 1

λ	ω	λ	ω
434*G′*	2.584	546Hg	2.250
436Hg	2.557	578Hg	2.224
442.4	2.491	589*D*	2.218
457.6	2.409	656*C*	2.185
486*F*	2.328	768*A′*	2.154

If $F < \lambda < A'$, $\epsilon = \omega + 0.011$.

55. $Ag_2S_2O_6.2H_2O$ (200)

λ	α	β	γ
486*F*	1.640_4	1.674_8	1.677_0
656*C*	1.627_2	1.657_3	1.660_1

56. Ag_3AsS_3 *ca.*, Proustite; *see* Fig. 2

γ	ω	ϵ	Lit.
589*D*	3.090+	2.794	(98)
589*D*	3.087+	2.792+	(41)
656*C*	2.991+	2.720	(98)
671Li	2.979	2.711+	(41)

Dispersion of (41) is 5% less than that of (98).

57. $PbTlAgAs_4S_8$ *ca.*, Hutchinsonite (187)

λ	α	β	γ
589*D*	3.08	3.176	3.188
656*C*	2.78	3.063	3.073

58. $AuS(CH_2.C_6H_5)_2Cl$, Aurodibenzylsulfine chloride (191)

λ	ω	ϵ
535Tl	1.774	1.717
589*D*	1.761	1.705
671Li	1.753	1.693

59. $Mn(NH_4)_2(SO_4)_2.6H_2O$; *see* Table 2

60. $Mn(NH_4)_2(SeO_4)_2.6H_2O$; *see* Table 2

61. $Mn_3(AsO_4)_2.4Mn(OH)_2$, Allactite (3)

λ	α	β	γ
486*F*	1.763_3	1.793_5	1.793_7
527*E*			1.786_9
589*D*			1.778_8
656*C*	1.755_2	1.773_1	1.773_2
687*B*			1.770_4

Uniaxial for λ = 573.

61.1. $MnSiF_6.6H_2O$ (200)

λ	ω	ϵ
486*F*	1.360_5	1.377_4
589*D*	1.357_0	1.374_2
656*C*	1.355_2	1.372_1

61.2. $MnTl_2(SO_4)_2.6H_2O$; *see* Table 2

61.3. $MnTl_2(SeO_4)_2.6H_2O$; *see* Table 2

62. Fe_2O_3, Hematite (238); *P*; *see* Fig. 2

λ	ω	ϵ
589*D*	3.22*	2.94*
656*C*	3.04_2	2.79_7
687*B*	2.98_8	2.75_9
719*a*	2.94_9	2.72_5
760*A*	2.90_4	2.69_0

* Extrapolated.

63. $FeO.OH$, Goethite (154.1); *P*

λ	α	β	γ
589*D*	2.26_0	2.39_4	2.40_0
612*	2.24_5	2.37_7	2.37_7
671Li	2.21_8	2.34_2†	2.33_9†

* For λ = 612, β = γ, crystal is uniaxial.

† These correspond to same directions as the preceding, but, owing to changes in *n*, the first (2.34_2) is now γ and the second is β.

64. $FeO.OH$, Lepidocrocite (154.1); *P*

λ	α	β	γ
589*D*	1.93_8	2.20	2.51_5
671Li	1.91_9	2.15+	2.42_5

64.1. $FeSO_4.7H_2O$, Melanterite (64.2); *P*

λ	α	β	γ
589*D*	1.471_3	1.478_2	1.485_6
671Li	1.468_1	1.474_8	1.482_4

65. $Fe_2O_3.2SO_3.H_2O$ (154.2); *P*

λ	α	β	γ
486*F*	1.814	1.844	1.968
535Tl	1.796	1.821	1.940
589*D*	1.783	1.804	1.918
671Li	1.770	1.788	1.894

66. $Fe_2O_3.2SO_3.5H_2O$ (154.2); *P*

λ	α	β	γ
486*F*	1.603	1.702	1.787
535Tl	1.594	1.688	1.765
589*D*	1.588	1.678	1.749
671Li	1.580	1.667	1.733

67. $Fe_2O_3.3SO_3$ (Orthorhombic form) (154.2); *P*

λ	α	β	γ
486*F*	1.844	1.857	1.861
535Tl	1.819	1.831	1.835
589*D*	1.802	1.814	1.818
671Li	1.785	1.797	1.801

68. $Fe_2O_3.3SO_3$ (Rhombohedral form) (154.2); *P*

λ	ω	ϵ
486*F*	1.809	1.798
535Tl	1.786	1.775
589*D*	1.770	1.760
671Li	1.754	1.744

69. $Fe_2O_3.3SO_3.6H_2O$ (154.2); *P*

λ	α	β	γ
486*F*	1.624	1.656	1.681
535Tl	1.613	1.644	1.667
589*D*	1.605	1.635	1.657
671Li	1.597	1.626	1.646

70. $Fe_2O_3.3SO_3.7H_2O$ (154.2); *P*; *cf.* Fig. 1

λ	α	β	γ
486*F*	1.585	1.603	1.666
535Tl	1.578	1.593	1.651
589*D*	1.572	1.586	1.640
671Li	1.565	1.578	1.629

71. $Fe_2O_3.4SO_3.9H_2O$, Rhomboclase (154.2); *P*

λ	α	β	γ
486*F*	1.545	1.564	1.657
535Tl	1.538	1.556	1.644
589*D*	1.533	1.550	1.635
671Li	1.528	1.544	1.625

72. $2Fe_2O_3.5SO_3.17H_2O$, Copiapite (154.2); *P*

λ	α	β	γ
486*F*	1.542	1.559	1.620
535Tl	1.536	1.552	1.606
589*D*	1.531	1.546	1.597
671Li	1.526	1.540	1.587

73. $3Fe_2O_3.4SO_3.9H_2O$, Borgströmite (154.2); *P*

λ	ω	ε
486*F*	1.865	1.755
535Tl	1.836	1.739
589*D*	1.816	1.728
671Li	1.797	1.716

74. $Fe(NH_4)_2(SO_4)_2.6H_2O$; *see* Table 2

75. $Fe(NH_4)_2(SeO_4)_2.6H_2O$; *see* Table 2

76. $FeCO_3$ *ca.*, Siderite (94, 133)

λ	ω	ε
436Hg	1.9025	
486F	1.8893	
535Tl	1.880_3	1.635_6
546Hg	1.8783	
589*D*	1.8726	1.632_1
656*C*	1.8658	
671Li	1.8645	1.628_5

77. $FeC_2O_4.2H_2O$, Ferrous oxalate (133); *P*

λ	α	β	γ
486*F*	1.461	1.594	1.716
589*D*	1.455	1.580	1.690
656*C*	1.453	1.574	1.681

78. $Fe_2(NH_4)_6(C_2O_4)_6.6H_2O$, Ferric-ammonium oxalate (133); *P*

λ	α	β	γ
486*F*	1.520	1.586	1.629
589*D*	1.510	1.570	1.610
656*C*	1.506	1.564	1.603

79. $FeSiF_6.6H_2O$, Ferrous fluosilicate (50)

λ	ω	ε
535Tl	1.3656	1.3867
589*D*	1.3638	1.3848
671Li	1.3619	1.3828

79.1. $FeTl_2(SO_4)_2.6H_2O$; *see* Table 2

79.2. $FeTl_2(SeO_4)_2.6H_2O$; *see* Table 2

80. $CoF_2.5HF.6H_2O$ (133); *P*

λ	ω	ε
434*G′*	1.390	1.406+
589*D*	1.384	1.399
656*C*	1.382	1.397

81. $Co(NH_4)_2(SO_4)_2.6H_2O$; *see* Table 2

82. $Co(NH_4)_2(SeO_4)_2.6H_2O$; *see* Table 2

82.1. $CoTl_2(SO_4)_2.6H_2O$; *see* Table 2

82.2. $CoTl_2(SeO_4)_2.6H_2O$; *see* Table 2

83. $NiF_2.5HF.6H_2O$ (130, 133); *P*

λ	ω	ε
434*G′*	1.398	1.413
589*D*	1.392−	1.408−
656*C*	1.390	1.406

84. $NiSO_4.6H_2O$ (200); *p*

λ	ω	ε
486*F*	1.517_3	1.493_0
589*D*	1.510_9	1.487_3
656*C*	1.507_8	1.484_4

85. $NiSO_4.7H_2O$, Morenosite (43.1, 200); *p*

λ	α	β	γ
589*D*	1.469_0	1.489_2	1.492_2
486*F*	$\delta\alpha_D = \delta\beta_D = \delta\gamma_D = 6_0$; $2V_D = 41° 55'$		

86. $NiSeO_4.6H_2O$ (200); *p*

λ	ω	ε
486*F*	1.547_3	1.519_6
589*D*	1.539_3	1.512_5
656*C*	1.535_7	1.508_9

87. $Ni(NH_4)_2(SO_4)_2.6H_2O$; *see* Table 2

88. $Ni(NH_4)_2(SeO_4)_2.6H_2O$; *see* Table 2

89. $NiSiF_6.6H_2O$ (200)

λ	ω	ε
486*F*	1.395	1.411
589*D*	1.391	1.407
656*C*	1.388	1.404

90. $NiTl_2(SO_4)_2.6H_2O$; *see* Table 2

91. $NiTl_2(SeO_4)_2.6H_2O$; *see* Table 2

92. MoS_2, Molybdenite*

92.—(*Continued*)

λ	ω
(221)	
500	5.6
555	5.0
593	4.7
620	5.4
655	4.9
680	5.9
$t = 18°$ (38)	
705	11.3
721	8.5
732	7.9
800	6.0
3000	4.0
7000	3.9
$t = -190°$ (38)	
676	14.8
685	9.9
705	7.9
732	6.2

* *See* Vol. V, p. 250.

93. $PbMoO_4$ *ca.*, Wulfenite* (14)

λ	ω	ε
501.8	2.485	2.326
527.0	2.454†	
587.6	2.408+	2.277
589.3*D*	2.405+†	
667.8	2.372	2.257
686.7	2.362†	

* By (60) the birefringence is 0.007 to 0.009 less than that tabulated.

† By (98) 0.002+ lower than values by (14).

94. $(NH_4)UO_2(C_2H_3O_2)_3$, Ammonium-uranyl acetate (177); *p*

λ	ω	ε
527*E* *ca.*	1.4862	1.4987
589*D*	1.4808	1.4933
687*B* *ca.*	1.4754	1.4877

94.1. $(NH_4)_2UO_2Cl_4.2H_2O$ (142.1)

95. $Pb_5V_3O_{12}Cl$, Vanadinite (26)

λ	ω	ε
589*D*	2.35_8	2.31_1
656*C*	2.34_1	2.29_2

96. $(SbO)_2(Ta, Cb)_2O_6$, Stibiotantalite (149)

λ	α	β	γ
39% Ta_2O_5 and 17.5% Cb_2O_5			
535Tl	2.401_4	2.434_2	2.487_6
589*D*	2.374_2	2.403_9	2.456_8
671Li	2.347_0	2.375_0	2.427_5
22.5% Ta_2O_5 and 30% Cb_2O_5			
535Tl	2.426_1	2.450_8	2.490_3
589*D*	2.397_7	2.419_0	2.458_8
671Li	2.368_6	2.387_6	2.428_0

97. Al_2O_3, Corundum (27, 122); *P*; *cf.* Fig. 1

589*D*, $\omega = 1.768$, $\epsilon = 1.760$

λ	$\delta\omega_D$ (133)	λ	$\delta\omega_D$ (133)
436Hg	138	656*C*	−33
486*F*	76	706He	−51
546Hg	27		

$\delta\epsilon_D = 0.97\delta\omega_D$; $\omega_D - \epsilon_D = 0.0081$(27, 122).

98. $Al_2C_{12}O_{12}.18H_2O$, Mellite (177)

λ	ω	ε
527*E* *ca.*	1.5435	1.5146
589*D*	1.5393	1.5110
687*B* *ca.*	1.5345	1.5079

99. $Al_2O_3.SiO_2$, Cyanite (196)

λ	α	β	γ
589*D*	1.713	1.722	1.728
λ........	434*G′*	486*F*	656*C*
$\delta\beta_D$ (133)	13_3	7_4	-2_9

$\delta\alpha_D = \delta\gamma_D = \delta\beta_D$; $-2V = 80°$ *ca.* (196).

100. $Al_2O_3.SiO_2$, Sillimanite (133); *p*; specimen contains 0.5% Fe

λ	α	β	γ
589*D*	1.661	1.662	1.682+
λ......	436Hg	486*F*	656*C*
$\delta\beta_D$....	136	76	−32

$\delta\alpha_D = \delta\gamma_D = \delta\beta_D$; ranges (121, 188, 196): $\alpha_D = 1.653$ (61), $\gamma_D = 1.675$(84), $+2V_D = 26$ to 31°.

101. $Al_2O_3.SiO_2$, Andalusite (196)

λ	α	β	γ
486*F*	1.639	1.645	1.651
589*D*	1.633	1.639	1.644
656*C*	1.630	1.636	1.641

102. $Al_2F_2SiO_4$, Topaz; (OH and Fe replacements) (139, 143, 150)

λ	$\delta\beta_D$\*	λ	$\delta\beta_D$\*
397*H*	138	589*D*	0
405Hg	129	656*C*	−23
434*G′*	97	706He	−36
486*F*	54	768*A′*	−51

$\delta\alpha_D = \delta\gamma_D = \delta\beta_D$; $\beta_D = 1.610$(33), $\beta_D - \alpha_D = 0.0014$ (28), $\gamma_D - \beta_D = 0.006_8$, $+2 \times V_C = 49$ to 67°, $2V_F = (2V_C - 2°)$.

λ	τ_α	τ_β	τ_γ
0 to 150° (143)			
480	0.7_5	0.8_5	0.7_9
671	0.7_7	0.7_7	0.7_7
150 to 300° (143)			
480	1.0_0	1.0_5	0.9_5
671	0.9_0	0.9_3	0.9_0

* Variations from 0.97 to 1.08 times these values are observed (171, 80, 133).

103. $4FeO.9Al_2O_3.8SiO_2.H_2O$ *ca.*, Staurolite (91); specimen contained *ca.* 2% Fe_2O_3

λ	α	β	γ
589*D*	1.7440	1.7497	1.7561

λ	$\delta\beta_D$	λ	$\delta\beta_D$
431*G*	166	656*C*	−38
486*F*	89	687*B*	−53
527*E*	48		

$\delta\alpha_D = 0.97\delta\beta_D$; $\delta\gamma_D = 1.07\delta\beta_D$.

104. **$Yt_2(MoO_4)_3$** (245); *P*

λ	$\omega(=\epsilon)$
535Tl	2.042
589*D*	2.027
671Li	2.012

105. **$Ce_2(MoO_4)_3$** (245); *P*

λ	ω	ϵ
535Tl	2.050	2.037
589*D*	2.034	2.022
671Li	2.018	2.006

106. **$CeLa(PO_4)_2$**, Monazite (34, 172, 174)

λ	α	β	γ
589*D*	1.789	1.790	1.843
	1.800	1.801	1.849
λ	$\delta\alpha_D$	$\delta\beta_D$	$\delta\gamma_D$
535Tl	5$_5$	5$_5$	6$_5$
671Li	−5$_7$	−5$_7$	−6$_4$

$+2V_D = 11$ to 15.5°.

107. **$Pr_2(SO_4)_3.8H_2O$** (51); *P*

λ	α	β	γ
535Tl	1.5430	1.5525	1.5641
589*D*	1.5399	1.5494	1.5607
671Li	1.5366	1.5459	1.5573

108. **$Pr_2(MoO_4)_3$** (245); *P*

λ..	535Tl	589*D*	671Li
ϵ..	2.015	2.002	1.989

Opt.—; probably $\omega = \epsilon$ *ca.*, *cf.* 111, **$Nd_2(MoO_4)_3$**.

109. **$Nd_2(SO_4)_3.8H_2O$** (51); *P*

λ	α	β	γ
535Tl	1.5441	1.5534	1.5652
589*D*	1.5413	1.5505	1.5621
671Li	1.5379	1.5469	1.5583

110. **$(Nd, Pr)_2(MoO_4)_3$** (245)

λ.	486F	535Tl	589*D*	671Li
ω.	2.054	2.037	2.025	2.011

$(\omega - \epsilon) > 0$, but very small.

111. **$Nd_2(MoO_4)_3$** (245); *P*; *cf.* Fig. 1

λ	ω	ϵ
486*F*	2.047	2.045
535Tl	2.029	2.027
589*D*	2.016	2.014
671Li	2.003	2.001

112. **$Sa_2(SO_4)_3.8H_2O$** (51); *P*

λ	α	β	γ
535Tl	1.5458	1.5551	1.5663
589*D*	1.5427	1.5519	1.5629
671Li	1.5395	1.5486	1.5594

113. **$3[(Yt, Er)_2O_3].3P_2O_5.SO_3$**, Hussakite (108)

λ	ω	ϵ
535Tl	1.7244	1.8196
589*D*	1.7207	1.8155
671Li	1.7166	1.8113

114. **$BeSO_4.4H_2O$**

For dispersion (200)

λ	ω	ϵ
486*F*	1.477$_9$	1.445$_0$
589*D*	1.472$_0$	1.439$_5$
656*C*	1.469$_1$	1.437$_4$

114.—(*Continued*)

For birefringence (241)

λ	ω	ϵ
486*F*	1.477	1.437
589*D*	1.471$_4$	1.432$_2$
656*C*	1.468$_6$	1.429$_9$

115. **$BeSeO_4.4H_2O$** (200); *p*

λ	α	β	γ
486*F*	1.472$_5$	1.508$_4$	1.510$_1$
589*D*	1.466$_7$	1.500$_7$	1.502$_7$
656*C*	1.463$_9$	1.497$_3$	1.499$_2$

116. **Be_2SiO_4**, Phenacite (143)

λ	ω	ϵ
480Cd	1.6607+	1.6767+
508Cd	1.6586	1.6745
538Cd	1.6566+	1.6725+
589*D*	1.6539+	1.6697+
644Cd	1.6515+	1.6673+
671Li	1.6506	1.6664

Interval	λ	τ_ω	τ_ϵ
0 to 150°	480	1.0+	1.0+
	671	1.0	1.0
150 to 300°	480	1.2	1.2
	671	1.1+	1.1+

117. **$Mn_2Be_2.2SiO_4$**, Trimerite (32)

λ	α	β	γ
535Tl	1.719	1.725	1.729
589*D*	1.715	1.720	1.725
671Li	1.712	1.717	1.722

117.1. **Be_2HBO_4**, Hambergite (59, 78)

λ	α	β	γ
589*D*	1.5595	1.5908	1.6311
	1.5530	1.5864	1.6272
	$2V$ = 87° 1$_2$′		

$2V_F - 2V_C = 9' - 5_0'$

λ	$\delta\beta_D$	λ	$\delta\beta_D$
404Hg	149	546Hg	+21+
436Hg	106	691Hg	−3$_6$
492Hg	57	760	−5$_5$

$\delta\alpha_D = 0.88\delta\beta_D$; $\delta\gamma_D = 1.10\delta\beta_D$

118. **$BeO.Al_2O_3$**, Chrysoberyl (121)

λ	α	β	γ
535Tl	1.748$_7$	1.751$_6$	1.757$_6$
589*D*	1.745$_2$	1.748$_1$	1.754$_0$
671Li	1.741$_2$	1.744$_0$	1.749$_8$

119. **$2BeO.Al_2O_3.2SiO_2.H_2O$**, Euclase (227)

λ	α	β	γ
447He	1.6606	1.6653	1.6814
502He	1.6560	1.6605	1.6767
588He	1.6508	1.6553	1.6714
668He	1.6474	1.6521	1.6677

120. **$Be_3Al_2Si_6O_{18}$** *ca.*, Beryl (44, 133, 143)

λ	ω	ϵ
404Hg	1.5917	1.5846
447He	1.5869	1.5800
502He	1.5826	1.5757
588He	1.5778	1.5711
668He	1.5746	1.5682
768*A*′	1.5717	1.5654

120.—(*Continued*)

Range (57, 113, 172): Dispersion *ca.* 15%, birefringence *ca.* 0.003, ω and ϵ *ca.* 0.025.

Interval	λ	τ_ω	τ_ϵ
0 to 150° (143)	480	1.2+	1.2
	671	1.2	1.1
150 to 300°	480	1.4	1.3
	671	1.3+	1.2+

120.1. **Mg** (78.2)

λ	n_1*	n_2*
416	0.26	0.31
440	0.29	0.34
496	0.29	0.37
520	0.33	0.39
560	0.38	0.42
589	0.34	0.39
620	0.32	0.42
650	0.32	0.42

* Electric vector ‖ optic axis for n_1, ⊥ for n_2; by comparison with Se, $n_2 = \omega$ and $n_1 = \epsilon$(?).

121. **$Mg(OH)_2$**, Brucite (233); *cf.* (59)

λ	ω	ϵ
	20°C	
447He	1.579$_4$	1.594$_9$
502He	1.573$_0$	1.590$_2$
588He	1.566$_2$	1.585$_3$
589*D*	1.561*	1.581*
706He	1.561$_7$	1.581$_5$
	100°C	
502He	1.573$_0$	1.589$_7$
588He	1.566$_2$	1.584$_8$
706He	1.561$_6$	1.580$_8$
	200°C	
502He	1.572$_0$	1.588$_3$
588He	1.565$_4$	1.583$_5$
706He	1.560$_7$	1.579$_4$

* From (102.1).

122. **$MgSO_4.7H_2O$**, Epsomite (21, 200); *P*; *cf.* Fig. 1

λ	α	β	γ
226Cd	1.4990	1.5266	1.5326
231Cd	1.4950	1.5223	1.5284
257Cd	1.4786	1.5049	1.5109
275Cd	1.4705	1.4963	1.5023
340Cd	1.4528	1.4774	1.4832
347Cd	1.4516	1.4762	1.4820
361Cd	1.4492	1.4736	1.4794
434*G*′	1.440$_6$*	1.464$_4$*	1.470$_1$*
486*F*	1.437$_0$*	1.460$_4$*	1.466$_0$*
589*D*	1.432$_2$*	1.4553*	1.460$_8$*
589*D*	1.4323	1.4553	1.4607
656*C*	1.4300*	1.4528*	1.458$_3$*

$-2V_D$ = 51° 25′.

* Recalculated from data of (43.2, 200).

123. **$Mg(NH_4)_2(SO_4)_2.6H_2O$**, Boussingaultite; *see* Table 2

124. **$Mg(NH_4)_2(SeO_4)_2.6H_2O$**; *see* Table 2

125. **$MgC_4H_4O_5.5H_2O$** (Malate) (136); *P*

λ	α	β	γ
431*G*	1.483	1.509	
486*F*	1.479	1.502	1.508
589*D*	1.473	1.497	1.501
656*C*	1.470	1.494	1.498

126. **Mg_2SiO_4**, Forsterite (olivine) (133); *P*; for other olivines, *see* 131, 154

λ	α	β	γ
431*G*	1.6492+	1.6645+	1.6829
436Hg	1.6486	1.6639	1.6822
486*F*	1.6431	1.6582	1.6764
546Hg	1.6385	1.6534	1.6715
578Hg	1.6365	1.6513+	1.6694+
589*D*	1.6359	1.6507	1.6688
656*C*	1.6329	1.6475	1.6655
668He	1.6324+	1.6470	1.6650

$2V_C$ = 84.9°; $2V_G$ = 85.7°.

127. **$MgSiF_6.6H_2O$** (200)

λ	ω	ϵ
486*F*	1.347$_3$	1.363$_4$
589*D*	1.343$_9$	1.360$_2$
656*C*	1.342$_7$	1.358$_7$

129. **$2(Pb, Mg)O.SiO_2.H_2O$** *ca.*, Molybdophyllite (69)

129.1. **$MgTl_2(SO_4)_2.6H_2O$**; *see* Table 2

129.2. **$MgTl_2(SeO_4)_2.6H_2O$**; *see* Table 2

130. **$MgPt(CN)_4.7H_2O$** (73)

λ	ω	ϵ
589*D*	1.561	1.91
656*C*	1.558	1.905
687*B*	1.555	

131. **$2(Mg, Fe)O.SiO_2$**, Chrysolite or olivine (64.1); *cf.* 126

λ	$\delta\beta_D$	λ	$\delta\beta_D$
410*h*	200	589*D*	0
431*G*	161	656*C*	−35+
486*F*	86	719*a*	−61
527*E*	46	761*A*	−75

Samples averaged 16 wt. % ($FeO + Fe_2O_3 + MnO$). α_D = 1.66$_5$; $\beta_D - \alpha_D$ = 0.0186; $\gamma_D - \beta_D$ = 0.0189. $\delta\alpha_D = 0.94\delta\beta_D$; $\delta\gamma_D = 1.02\delta\beta_D$. $2V_G$ = 88° 34′; $2V_C$ = 90° 1′.

132. **$MgCrO_4.7H_2O$** (200)

λ	α	β	γ
589*D*	1.521	1.550	1.568
656*C*	1.513	1.541	1.563

133. **$Mg(NH_4)_2(CrO_4)_2.6H_2O$** (133, 220); *see* Table 2

134. **$Mg_7B_{16}O_{30}Cl_2$** (?), Boracite (118)

Isotropic if $t \gtreqless$ 290°C; at 290°, $n_D = 1.671$, $n_{502} - n_{588}$ = 0.0060; $\tau = +1.0$ if 290° < t < 650°C. Just below inversion point (*ca.* 290°) n exceeds above values by 0.004 *ca.*

135. **$Mg_5Al_2H_8Si_3O_{18}$** *ca.*, Penninite (98, 157)

λ	$\delta\beta_D$	λ	$\delta\beta_D$
486*F*	7$_8$	589*D*	0
535Tl	3$_5$	671Li	−3$_7$

$\alpha_D = \beta_D = \gamma_D = 1.58$.

136. $3MgO.FeO.4Al_2O_3.10SiO_2.H_2O$ *ca.*, Cordierite (145)

λ	α	β	γ
589*D*	1.533 1.552	1.537 1.556	1.541 1.561

λ	$\delta\beta_D$	λ	$\delta\beta_D$
393*K*	17_1	486*F*	62+
410*h*	145	656*C*	−26+
434*G′*	113	760*A*	−56

$\delta\alpha_D$, $\delta\beta_D$, $\delta\gamma_D$ are alike; variations of ±5%. For $20° < t < 320°$, $\tau_\alpha = \tau_\beta = \tau_\gamma = 1.3$, same for all λ's (143); *cf.* (145). For effects of radiation from Po, *see* (92).

137. Mg-tourmaline; *see* 225

137.1. $CaSO_4$, Anhydrite (61, 103, 115, 139); *P*

λ	α	β	γ
589*D*	1.5693 1.5698	1.5752 1.5757	1.6130 1.6139

λ	$\delta\beta_D$	λ	$\delta\beta_D$
431*G*	103	687*B*	−31
486*F*	55	619*a*	−39+
656*C*	−22+		

$\delta\alpha = 0.97\delta\beta$; $\delta\gamma = 1.11\delta\beta$.

λ	τ_α	τ_β	τ_γ
	$-50° < t < 205°$		
431	−0.3	−0.6	−1.0
687	−0.4	−0.6	−1.0
	$205° < t < 560°$		
431	−0.5+	−0.5+	−1.4
687	−0.5	−0.7	−1.4+

138. $CaSO_4.2H_2O$, Gypsum (47, 97, 107); *P*

λ	α	β	γ
589*D*	1.5195 1.5208	1.5216 1.5230	1.5283 1.5305

λ	$\delta\beta_D$	λ	$\delta\beta_D$
434*G′*	98	687*B*	−34
486*F*	54+	760*A*	-5_4
656*C*	−24		

$\delta\alpha_D = 0.99\delta\beta_D$; $\delta\gamma_D = 1.03 \times \delta\beta_D$. At 20°C, $+2V_D = 60°$ *ca.*, $2V_C = 2V_D - 24'$ to $-28'$, $2V_F = 2V_D - 31'$ to $-43'$. If $12° < t < 90°$, $\tau_\alpha = -1.1$, $\tau_\beta = -4.2$, $\tau_\gamma = -2.4$ for blue; and $\tau_\alpha = -1.5$, $\tau_\beta = -4.5$, $\tau_\gamma = -2.8$ for red. Becomes uniaxial near 90°C.

139. $CaS_2O_6.4H_2O$ (167); *cf.* (17); *p*

λ	ω	ε
436Hg	1.564_9	1.551_6
492Hg	1.558_0	1.546_7
546Hg	1.554_1	1.543_1
589*D*	1.551_6	1.541_4
623Hg	1.549_8	1.539_9

140. $3Ca_3P_2O_8.Ca(F, Cl)_2$ *ca.*, Apatite (13, 29, 226, 247, 249)

λ	$\delta\omega_D$ (59)	λ	$\delta\omega_D$ (59)
405Hg	171+	546Hg	25
434*G*	127+	656*C*	−29
486*F*	71	706He	−46

With 589*D*; $\omega = 1.633$ to 1.667, $\epsilon_D = \omega_D - (0.001$ to $0.004+)$. $\delta\epsilon_D = 0.96\delta\omega_D$ to $0.98\delta\omega_D$, range (13, 63, 85, 228) of $\delta\omega_D$ and $\delta\epsilon_D = \pm 4\%$ from tabulated values. For $0° < t < 600°C$ (63) $\tau_\omega = -0.2_5$, $\tau_\epsilon = -0.5_4$ for λ = 471; and $\tau_\omega = -0.3_5$, $\tau_\epsilon = -0.6_4$ for λ = 706. Discontinuity (?) in ω and ε at $t = -50°C$.

141. $CaCO_3$, Aragonite (171); *P*

λ	α	β	γ
397*H*	1.5422+	1.7051	1.7101
431*G*	1.5388	1.6983+	1.7032
486*F*	1.5348	1.6905+	1.6951+
527*E*	1.5326+	1.6863+	1.6908+
589*D*	1.5301+	1.6815+	1.6859
656*C*	1.5282	1.6778	1.6820+
687*B*	1.5275	1.6763	1.6806

Indices for *D* vary ±0.0003 *ca.* (44, 115, 118, 143, 182). Slow irreversible change at 320°.

λ	τ_α	τ_β	τ_γ	Lit.
	$0° < t < 300°$			
471	-1.2	−2.5	−2.9	(118)
480	−1.3+	−2.5	−2.7+	(143)
671	−1.4	−2.5+	−2.8	(143)
706	-1.1	−2.7	−3.0	(118)

142. $CaCO_3$, Calcite, Iceland spar (33, 37, 75, 83, 119, 173); *P*; *cf.* Fig. 1; for X-rays, Mo$K\alpha_1$, $\lambda = 0.07077_2$, $\omega = \epsilon(?) = 0.9999980$ (83)

λ*	$\omega_{18°}$†	$\epsilon_{18°}$†
198.98Al		1.5781_4
200.06Au	1.9030_2	1.5766_3
204.448Au	1.8826_3	1.5709_8
208.20Au	1.8674_3	1.56654
211.07Au	1.85695	1.56340
214.439Cd	1.8457_4	1.55989
219.462Cd	1.8308_6	1.55511
223.986Cd	1.8190_3	1.55117
226.503Cd	1.81300	1.54914
228.803Cd	1.80778	1.54736
230.663Cd	1.80377	1.54596
231.288Cd	1.80246	1.54551
232.115Cd	1.80075	1.54491
242.796Au	1.78121	1.53783
257.304Cd	1.76048	1.53013
274.867Cd	1.74147	1.52267
291.358Au	1.72776	1.51728+
298.062Cd	1.72304	1.51511
303.412Sn	1.71956	1.51366
312.923Cd	1.71393	1.51128+
330.28Zn	1.70516	1.50752
340.365Cd	1.70080	1.50561
361.2_5Cd	1.69314	1.50223
394.402Al	1.68374	1.49803
396.154Al	1.68331	1.49782+
396.848Ca*H*	1.68314	1.49775
404.656Hg	1.68134	1.49694
410.174$H_\delta h$	1.68014	1.49639
430.78+*G*	1.67610+	1.49454+
434.047$H_\gamma G'$	1.67552+	1.49428
435.834Hg	1.67520	1.49414
447.148He	1.67331+	1.49327+
471.315He	1.66976+	1.49164
486.133$H_\beta F$	1.66785	1.49076
491.60Hg	1.66719	1.49045
492.193He	1.66711+	1.49042
501.568He	1.66604+	1.48992+
526.99_5Fe 527.01*E*	1.66341+	1.48873+
535.047Tl	1.66267	1.48838
546.072Hg	1.66168+	1.48792+
576.960Hg	1.65921+	1.48681
579.066Hg	1.65906+	1.48674
587.563He	1.65846+	1.48647
589.29Na*D*	1.65836+	1.48641+
643.847Cd	1.65503+	1.48491
656.278$H_\alpha C$	1.65438	1.48461+
667.815He	1.65381+	1.48436+
670.786Li	1.65367	1.48430
687.2*B*	1.65290+	1.48396
706.520He	1.65207	1.48359
718.9*a*	1.65156+	1.48337+
760.7*A*	1.65000	1.48269+
768.19K*A′*	1.64974	1.48258
800.7	1.64867	1.48212
904.7	1.64579	1.48095
1041.7	1.64276	1.47982
1159.2	1.64052	1.47907
1307.0	1.63790	1.47828
1497.2	1.63459+	1.47741+
1614.6		1.47692
1681.5	1.63126	
1847.8	1.62802+	
1908.5		1.47570
1945.7	1.62603	
2053.1	1.62371	
2099.8		1.47489
2171.9	1.62099	
2324.3		1.47389
640_0	0.76	(120.1)
650_0	0.13	
660_0	0.07	
680_0	0.11	
690_0	0.34	
695_0	0.35	
700_0	0.36	
705_0	0.67	
710_0	2.9	

λ	τ_ω‡	τ_ϵ‡
$t = 61.5°C$ (134, 161); *cf.* (147)		
211.07	2.2	
214.44	2.0_2	2.62
219.46	1.8_2	2.45
226.50		2.29
231.29	1.4_2	2.21
257.30	0.9_5	1.89
274.87	0.7_6	1.76
298.0	0.6_0	1.64
312.9	0.53	
340.36	0.44	1.49
361.25	0.40	1.43
396.85*H*	0.33	1.36
434.05*G′*	0.30	1.32
486.13*F*	0.25	1.27
589.29*D*	0.21	1.21
589.29*D*	0.21§	1.19§
656.28*C*	0.19	1.18
t	$\tau_{\omega D}$‖	$\tau_{\epsilon D}$‖
18	0.07_1¶	1.05¶
57.1	0.07_8	1.094
61.5	0.07_9¶	1.10¶
152.5	0.100	1.185
248.5	0.132	1.313
349.0	0.168	1.435

* In air at 15°C and 760 mm of Hg (101.1).

† All values on smooth curve.

‡ In air.

§ At 18°; calculated (134, 161).

‖ In vacuum (161).

¶ From curve.

143. $CaC_2O_4.H_2O$ (Oxalate) (Whewellite) (100); *p*

λ	α	β	γ
535Tl	1.493_4	1.559_9	1.656_7
589*D*	1.490_9	1.555_4	1.650_2
671Li	1.487_8	1.551_3	1.645_0

144. $Ca(CHO_2)_2$ (Formate) (178)

λ	α	β	γ
527*E* *ca.*	1.5132	1.5167	1.5819
589*D*	1.5101	1.5135	1.5775
687*B* *ca.*	1.5067	1.5100	1.5731

145. $CaH_2(C_4H_4O_5)_2.6H_2O$ (Acid malate) (178)

λ	α	β	γ
527*E* *ca.*	1.4972	1.5112	1.5492
589*D*	1.4933	1.5073	1.5449
687*B* *ca.*	1.4887	1.5029	1.5404

146. $CaSiO_3$ (65); *P* (high-temperature form)

λ	α	β	γ
486*F*	1.618	1.618	1.663
589*D*	1.610	1.610	1.654
656*C*	1.607	1.607	1.649

147. $Ca_3Si_2O_7.3H_2O$, Afwillite (147.1); *P*

λ	α	β	γ
546Hg	1.620	1.623+	1.636+
589*D*	1.617	1.620+	1.633+
668He	1.615	1.618	1.631

148. $CaTiSiO_5$ *ca.*, Titanite, sphene; *cf.* Fig. 1; zoned specimen (82)

λ	α	β	γ
589*D*	1.88_0	1.88_8	2.00_7
λ	$\delta\alpha_D$	$\delta\beta_D$	$\delta\gamma_D$
460 *ca.*	32_2	28_3	53_2
486*F* *ca.*	23_2	20_3	37_7
656*C* *ca.*	-8_1	-7_3	-13_6
719*a* *ca.*	-14_6	-12_6	-22_8

For purest specimens, $\alpha_D = 1.88(1.91)$, $\gamma_D = 1.98(2.05)$, $\beta_D = \alpha_D + 0.002(8) = \gamma_D - 0.08(13)$; $+2V_D = 24°(32°)$; $2V_C = 2V_F + 10°$ *ca.* (33, 82).

149. $PbCa_2(C_3H_5O_2)_6$ (Propionate) (71)

λ	ω	ε
535Tl	1.531_0	1.543_6
589*D*	1.526_8	1.538_9
671Li	1.523_1	1.534_1

150. **$2CaO.ZnO.2SiO_2$**, Hardystonite (93); specimen was 94 %
$2CaO.ZnO.2SiO_2$

λ	ω	ϵ
410*h ca.*	1.6941	1.6810
434*G′ ca.*	1.6893	1.6766
486*F ca.*	1.6815	1.6696
589*D ca.*	1.6720	1.6606
656*C ca.*	1.6681	1.6570
719*a ca.*	1.6653	1.6544

151. **$CaPt(CN)_4.5H_2O$** (12); *p*; *see* Fig. 2

λ	α	β	γ
486*F*	1.636_1		
492He			1.994
502He	1.633_6	1.655_0	1.949+
588He	1.622_8	1.644_4	1.767
688He	1.616_9	1.638_3	1.708
706He			1.691+

152. **$Ca_2Fe(CN)_6.12H_2O$** (50); *p*

λ	α	β	γ
535Tl	1.5753	1.5871	1.6017
589*D*	1.5700	1.5818	1.5961
671Li	1.5646	1.5764	1.5902

153. **$CaFeSi_2O_6$**, Hedenbergite (237)

154. **$5Fe_2SiO_4.4Ca_2SiO_4$**, Olivine (or iron-monticellite) (93); *cf.* 126; specimen was 92 %
$5Fe_2SiO_4.4Ca_2SiO_4$

λ	α	β	γ
410*h*	1.7200	1.7628	1.7711
434*G′*	1.7146	1.7562	1.7648
486*F*	1.7062	1.7460	1.7547
589*D*	1.6958	1.7340	1.7430
656*C*	1.6913	1.7291	1.7383
719*a*	1.6884	1.7256	1.7351

155. **$CaMoO_4$** (245); *p*; *cf.* Fig. 1

λ	ω	ϵ
535Tl	1.981	1.992
589*D*	1.970	1.980
671Li	1.958	1.966

Specimen containing
$Yt_2(MoO_4)_3$

λ	ω	ϵ
535Tl	2.002	2.011
589*D*	1.989	1.998
671Li	1.977	1.985

Specimen containing 24.7 % $Yt_2(MoO_4)_3$ and 21 % $Ce_2(MoO_4)_3$

λ	ω	ϵ
535Tl	2.014	2.019
589*D*	2.000+	2.005
671Li	1.989	1.992

156. **$CaWO_4$**, Scheelite (245); *P*; pure $CaWO_4$

λ	ω	ϵ
535Tl	1.928+	1.945
589*D*	1.920	1.936+
671Li	1.911	1.927

Addition of 10.3 % $Ce_2(WO_4)_3$ increases ω by 0.006+ and ϵ by 0.004+.

157. **$2CaO.3B_2O_3.5H_2O$**, Colemanite (139); *cf.* (227)

λ	α	β	γ
486*F*	1.5921	1.5981	1.6204
589*D*	1.5863	1.5920	1.6140
656*C*	1.5835	1.5892	1.6110
687*B*	1.5823	1.5881	1.6098

158. **$CaB_2Si_2O_8$**, Danburite* (89.1)

λ	α	β	γ
535Tl	1.6339	1.6366	1.6393
589*D*	1.6309	1.6337	1.6363
671Li	1.6273	1.6303	1.6331

* Data for α recalculated.

159. **$CaAl_2Si_2O_8$**, Anorthite; *P*; for other feldspars, *v.* 261

λ	α	β	γ
589*D*	1.576*	1.584*	1.589*

For specimen of 3.9M % albite (218); (105)

λ	α	β	γ
486*F*	1.5807	1.5888	1.5947
535Tl	1.5770	1.5851	1.5906
589*D*	1.5738	1.5818	1.5872
671Li	1.5702	1.578_7	1.5834
687*B*	1.5697	1.578_3	1.5828

λ...	486	535	589	671
$-2V$.	78°+	77°+	77°	76°+

* By extrapolation from impure specimens, and for synthetic material (123, 236.1).

160. **$(CaAl_2Si_2O_8)y + (NaAlSi_3O_8)x$**, Feldspars; *see* 229

161. **$Ca_2Al_3HSi_3O_{13}$**, Clinozoisite (epidote) (77, 185, 244); for Fe-epidote, *see* 163

λ	α	β	γ
589*D*	1.714	1.717	1.719

λ	$\delta\beta_D$
486*F ca.*	9_0
527*E ca.*	5_0
656*C ca.*	-4_0

Approximately $\delta\alpha_D = \delta\beta_D = \delta\gamma_D$.

162. **$Ca_4Al_6Si_6O_{25}\ (CO_3)$** *ca.*, Meionite (22, 28, 88, 117.1, 237)

λ	$\delta\omega_D$
486*F*	71
535Tl	31
656*C*	−30
671Li	−35
700	−45

With 589*D*, $\omega = 1.61+$, $\epsilon = \omega - 0.04_6$. $\delta\epsilon_D = 0.89\delta\omega_D$. Same values except of birefringence (?), for specimens containing SO_4. Scapolite is intermediate between Meionite and Marialite (221).

163. **$Ca_2(Al, Fe)_3HSi_3O_{13}$**, Epidote (77); specimen contains 37 atoms Fe to 63 atoms Al

λ	α	β	γ
589*D*	1.729	1.763	1.780

163.—(*Continued*)

Approximately $\delta\alpha_D = \delta\beta_D = \delta\gamma_D$ and probably increases with increase of Fe/Al, as do the refractivity and birefringence; *cf.* 161.

164. **$Ce(La, etc.)(CO_3)_3.CaF_2$** *ca.* Parisite (158)

λ	ω	ϵ
453	1.684	1.788
533	1.676	1.775+
535Tl	1.676_7*	1.772_9*
589*D*	1.672	1.770
589*D*	1.674_2*	1.770_1*
667	1.668+	1.764+
671Li	1.671_8*	1.766_4*

* From (70).

165. **$Ca_3(Ce, La, Nd, Pr)_4Si_3O_{15}$**, Beckelite (110)

166. **$2CaO.5MgO.Al_2O_3.F_2.7SiO_2$** *ca.*, Hornblende (109); *see also* 171

λ	α	β	γ
589*D*	1.614	1.618	1.633
535Tl	$(\delta\alpha = \delta\beta)_{671} = 6_2$, $\delta\gamma_{671} = 6_3$		

167. **$Ca_3Mg_3O_2F_8$** *ca.*, Nocerine (242)

λ	ω	ϵ
475	1.513_8	1.489_5
533	1.511_1	1.487_3
589*D*	1.509_1	1.485_6
633	1.507_6	1.484_8

168. **$CaMg(CO_3)_2$**, Dolomite (104) curves; *P*

λ	ω	ϵ	% FeCO
434*G′*	1.696_4	1.5091	0
486*F*	1.6893	1.5056	0
535Tl	1.6842	1.5032	0
	+13*	+10*	
	+122†	+83†	9.4
	+167†	+107†	11.9
589*D*	1.6799	1.5013	0
	+14*	+9*	
	+121†	+82†	9.4
	+165†	+105†	11.9
656*C*	1.6760	1.4995	0
671Li	1.6753	1.4992	0
	+14*	+10*	
	+118†	+83†	9.4
	+161†	+104†	11.9
768*A′*	1.6714	1.4974	

* Data (96) minus data (104).
† Data (23) minus data (104).

169. **$CaMgSi_2O_6$**, Diopside, (pyroxene) (128, 133); *P*

λ	α	β	δ
589*D*	1.664(6)	1.671(3)	1.694(5)

λ	$\delta\beta_D$	λ	$\delta\beta_D$
405Hg	187	535Tl	34+
434*G′*	140	656*C*	−32+
486*F*	77+	768*A′*	−71

169.—(*Continued*)

$\delta\alpha_D = \delta\beta_D$; $\delta\gamma_D = 1.05_5\delta\beta_D$. For specimens with *ca.* 4.7 % Fe_2O_3 and 5.1 % FeO, (augite) all δ's are 25% > δ's for diopside (98, 238).

170. **$2CaO.MgO.2SiO_2$**, Åkermanite (93); specimen has 95 %
$2CaO.MgO.2SiO_2$

λ	ω	ϵ
410*h*	1.659_1	1.662_3
434*G′*	1.655_2	1.658_5
486*F*	1.6478	1.6514
589*D*	1.6392	1.6431
656*C*	1.6355	1.6397
719*a*	1.633_2	1.637_4

For Melilite, *see* (35, 90).

171. **$2CaO.5MgO.H_2O.8SiO_2$** *ca.*, Tremolite (109)

λ	α	β	γ
589*D*	1.600	1.614	1.625
535Tl	$(\delta\alpha = \delta\beta)_{671} = 56$, $\delta\gamma_{671} = 65$		

172. **$Sr(ClO_3)_2$** (165)

λ	α	β	γ
486*F*	1.571_7	1.611_6	1.633_7
589*D*	1.567_0	1.604_7	1.625_7
687*B*	1.563_6	1.600_2	1.621_0

173. **$SrSO_4$**, Celestite (103, 115); *P*

λ	α	β	γ
589*D*	1.6214	1.6214	1.6305
	1.6220	1.6245	1.6309

δ's are 9 % less than for barite (178) (6, 103). For red and $-50° < t < +200°$, $\tau_\alpha = \tau_\gamma = -1.6$, $\tau_\beta = -1.3$; $200° < t < 500°$, $\tau_\alpha = -1.7$, $\tau_\beta = -1.6$, $\tau_\gamma = -2.2$. For blue, τ's about 10 % less (6, 103).

174. **$SrS_2O_6.4H_2O$** (167); *cf.* (17); *P*

λ	ω	ϵ
405Hg	1.5461	1.5391
436Hg	1.5417	1.5357
486*F*	1.5362	1.5315
492Hg	1.5357	1.5310
546Hg	1.5316	1.5278
579Hg	1.5297	1.5262
623Hg	1.5277	1.5246
656*C*	1.5263	1.5235
691Hg	1.5253	1.5226

175. **$Sr(CHO_2)_2$** (Formate) (154); *cf.* (178); *p*

λ	α	β	γ
535Tl	1.560	1.580	1.605
589*D*	1.559	1.574	1.598
671Li	1.555	1.571	1.594

175.1. **$Sr(CHO_2)_2.2H_2O$** (Formate) (178); *p*

λ	α	β	γ
527*E ca.*	1.4869	1.5244	1.5420
589*D*	1.4838	1.5210	1.5382
687*B ca.*	1.4806	1.5174	1.5342

176. $SrSiO_3$ (65); *P*

λ	α	β	γ
486*F*	1.606	1.606	1.646
589*D*	1.599	1.599	1.637
656*C*	1.596	1.596	1.634

177. Sr_2SiO_4 (65); *P*

λ	α	β	γ
486*F*	1.740	1.744	1.766
589*D*	1.727	1.732	1.756
656*C*	1.722	1.727	1.752

178. $SrPt(CN)_4.5H_2O$ (15)

179. $SrMoO_4$ (245); *P*; *cf.* Fig. 1

λ	ω	ε
535Tl	1.926	1.932
589*D*	1.917	1.922
671Li	1.906	1.910

180. $Ca_2Sr(C_3H_5O_2)_6$ (Propionate) (71); *p*

λ	ω	ε
535Tl	1.489_7	1.498_7
589*D*	1.487_1	1.495_6
671Li	1.483_9	1.491_7

181. $BaBr_2.2H_2O$ (54); *P*

λ	α	β	γ
486*F*	1.7282	1.7418	1.7588
535Tl	1.7197	1.7334	1.7507
589*D*	1.7129	1.7266	1.7441
656*C*	1.7067	1.7205	1.7382
671Li	1.7056	1.7194	1.7371

182. $BaSO_4$, Barite (56, 61, 85, 103, 115); *P*

λ	α	β	γ
589*D*	1.6360 1.6368	1.6372 1.6379	1.6480 1.6486

λ	$\delta\alpha_D$*	$\delta\beta_D$*	$\delta\gamma_D$*
397*H*	167+	170	176
431*G*	120+	122	126+
486*F*	64	65+	68
656*C*	−26	−26+	−27+
716*a*	−45	−46	−47

λ	τ_α	τ_β	τ_γ
$-50° < t < +215°$ (103)			
431	−1.7+	−1.4+	−2.3
686	−1.8	−1.6	−2.3
$215° < t < 560°$ (103)			
431	−2.0+	−1.8	−2.6
686	−2.1	−1.8	−2.6
$0° < t < 300°$ (143)			
480	−2.0	−1.7+	−2.5+
671	−2.0+	−1.8+	−2.6

* From (85, 103, 139, 143).

183. $Ba(CHO_2)_2$, (Formate) (178); *p*

λ	α	β	γ
527*E ca.*	1.578	1.602	1.641
589*D*	1.573	1.597	1.636
687*B ca.*	1.568	1.592	1.631

184. $BaSiO_3$ (65); *P*; *cf.* Fig. 1

λ	α	β	γ
486*F*	1.682	1.684	1.688
589*D*	1.673	1.674	1.678
656*C*	1.669	1.670	1.673

185. $BaSi_2O_4$ (65); *P*

λ	α	β	γ
486*F*	1.602	1.617	1.63_2
589*D*	1.597	1.612	1.621
656*C*	1.595	1.610	1.618

186. $Ba_2Si_3O_8$ (65); *P*

486*F*	1.627	1.632	1.652
589*D*	1.620	1.625	1.645
656*C*	1.617	1.622	1.641

187. $BaPt(CN)_4.4H_2O$ (12); *see* Fig. 2

187.1. $BaBe_2Si_2O_7$, Barylite (248); *p*

λ	α	β	γ
540	1.699	1.705	1.707
589*D*	1.691	1.696	1.703
656*C*	1.687	1.692	1.699

188. $BaCa_2Si_3O_9$ (65); *P*

λ	ω	ε
486*F*	1.690	1.678
589*D*	1.681	1.668
656*C*	1.677	1.664

189. $Li_2S_2O_6.2H_2O$ (200)

λ	α	β	γ
486*F*	1.554_8	1.568_0	1.588_7
589*D*	1.548_7	1.560_2	1.578_8
656*C*	1.546_2	1.556_5	1.576_3

190. $Li_2O.Al_2O_3.4SiO_2$, Spodumene (57)

λ	α	β	γ
589*D*	1.660	1.665	1.675

λ	$\delta\beta_D$
535Tl	31
671Li	−35

$\delta\alpha_D = \delta\beta_D$; $\delta\gamma_D = 1.06\delta\beta_D$.

191. $Na_2S_2O_3.5H_2O$ (46); *P*

λ	α	β	γ
535Tl	1.4919	1.5117	1.5405
589*D*	1.4886	1.5079	1.5360
671Li	1.4849	1.5038	1.5311

191.1. $NaNO_3$, Soda niter (133); *P*

λ	ω	ε
434*G′*	1.6126	1.340_4
436Hg	1.6121	1.340_3
486*F*	1.5998	1.338_4
501He	1.5968	1.337_9
546Hg	1.5899	1.336_5
578Hg	1.5860	1.336_3
589*D*	1.5848*	1.336_0*
656*C*	1.5791	1.334_7
668He	1.5783	1.334_5

* *Cf.* 102.1, 177).

192. $Na_4P_2O_7.10H_2O$ (45); *p*

λ	α	β	γ
535Tl	1.4526	1.4551	1.4629
589*D*	1.4499	1.4525	1.4604
671Li	1.4470	1.4496	1.4575

193. $NaHPO_3.3H_2O$ (45); *P*

λ	α	β	γ
535Tl	1.4883	1.4927	1.5074
589*D*	1.4855	1.4897	1.5041
671Li	1.4822	1.4861	1.5006

194. $NaH_2PO_4.H_2O$ (45); *P*

λ	α	β	γ
535Tl	1.4583	1.4881	1.4902
589*D*	1.4557	1.4852	1.4873
671Li	1.4527	1.4821	1.4841

195. $NaH_2PO_4.2H_2O$ (45); *P*

λ	α	β	γ
535Tl	1.4123	1.4655	1.4843
589*D*	1.4400+	1.4629	1.4814+
671Li	1.4376	1.4600	1.4782

196. $Na_2HPO_4.7H_2O$ (45); *P*

λ	α	β	γ
535Tl	1.4437	1.4449	1.4552
589*D*	1.4411+	1.4424	1.4526
671Li	1.4382	1.4395	1.4497

197. $Na_2HPO_4.12H_2O$ (45, 46); *P*

λ	α	β	γ
535Tl	1.4348	1.4389	1.4402
589*D*	1.4321	1.4361	1.4373
671Li	1.4290	1.4330	1.4341

198. $Na_2H_2P_2O_7.6H_2O$ (45); *P*

λ	α	β	γ
535Tl	1.4623	1.4672	1.4677
589*D*	1.4599	1.4645	1.4649
671Li	1.4573	1.4616	1.4617

199. $Na_3HP_2O_6.9H_2O$ (45); *P*

λ	α	β	γ
535Tl	1.4682	1.4769	1.4836
589*D*	1.4653	1.4738	1.4804
671Li	1.4622	1.4705	1.4769

200. $Na_3AsO_4.12H_2O$ (10); *P*

λ	ω	ε
535Tl	1.462_4	1.470_4
589*D*	1.458_9	1.466_9
671Li	1.455_3	1.463_0

201. $NaH_2AsO_4.H_2O$ (45); *P*

λ	α	β	γ
535Tl	1.5418	1.5573	1.5647
589*D*	1.5382	1.5535	1.5607
671Li	1.5341	1.5494	1.5563

202. $Na_2HAsO_4.7H_2O$ (45); *P*

λ	α	β	γ
535Tl	1.4654	1.4689	1.4814
589*D*	1.4622	1.4658	1.4782
671Li	1.4587	1.4623	1.4746

203. $Na_2HAsO_4.12H_2O$ (45); *P*

λ	α	β	γ
535Tl	1.4482	1.4527	1.4545
589*D*	1.4453	1.4495+	1.4513
671Li	1.4420	1.4462	1.4480

204. $NaSO_3.NH_2C_6H_4.2H_2O$ (Sulfanilate) (52); *P*

λ	α	β	γ
535Tl	1.5411	1.5722	1.6573
589*D*	1.5362	1.5667	1.6490
671Li	1.5312	1.5611	1.6405

205. $NaSO_3.C_{10}H_6NH_2.4H_2O$ (Naphthionate) (52); *P*

λ	α	β	γ
535Tl	1.5800	1.6067	1.665_7
589*D*	1.5731	1.5987	1.657_0
671Li	1.5660	1.5906	1.646_0

205.1. $(NH_4)NaC_4H_4O_6.4H_2O$ (Tartrate*) (8.1 81.1); *P*

λ	α	β	γ
436	1.504+	1.507+	1.508
546	1.497+	1.500+	1.501+
589*D*	1.495+	1.498+	1.499+
650	1.494	1.497	1.498

* Mixed crystals of this with the K-Na salt (8.1).

206. Na_2SiF_6 (160); *P*; *cf.* Fig. 1

λ	ω	ε
434*G′*	1.3153	1.3118
486*F*	1.3141	1.3106
589*D*	1.3125	1.3089
656*C*	1.3116	1.3081

207. $Na_2O.ZrO_2.6SiO_2.3H_2O$, Elpidite (70)

λ	α	β	γ
535Tl	1.563_2	1.567_4	1.577
671Li	1.557_5	1.562_0	1.570

207.1. $Na_2(Ti, Zr)O_2.Si_2O_7$, Lorenzenite (70)

λ	α	β	γ
535Tl	1.758		1.802
589*D*	1.743	1.74_8	1.788
671Li	1.732		1.778

$+2E_D = 7_2°$; $2V_D = 3_9°$

208. $Na_2Pt(CN)_4.3H_2O$ (15)

209. $Na_2Fe_2Si_4O_{12}$, Acmite (132); *P*

λ	α	β	γ
589*D*	1.77+	1.82	1.83+

Dispersion 6% greater than for the following, *p*:

434*G′*	1.801_7	1.854_4	1.877
436Hg	1.800_0	1.852_4	
486*F*	1.7853	1.8304	1.850+
502He	1.7818	1.8254	
546Hg	1.7736	1.8142+	
589*D*	1.7675	1.8062	1.823
656*C*	1.7608	1.7974	1.813
668He	1.7597	1.7961	

210. $Na_6FeTi_2Si_{12}O_{22}F$, Narsarsukite (70)

211. $Na_2CrO_4.4H_2O$(?) (40)

212. $Na_2O.P_2O_5.(MoO_3)_5.$-$14H_2O$ (50); *P*

λ	α	β	γ
535Tl	1.6017	1.6494	1.6610
589*D*	1.5962	1.6411	1.6520
671Li	1.5906	1.6328	1.6430

213. $Na_3VO_4.10H_2O$ (10); *P*

λ	ω	ε
535Tl	1.546_0	1.553_7
589*D*	1.539_8	1.547_5
671Li	1.533_2	1.540_8

214. $Na_3VO_4.12H_2O$ (10); P

λ	ω	ε
535Tl	1.515_0	1.5293
589*D*	1.509_5	1.5232
671Li	1.504_0	1.5173

215. $Na_2B_4O_7.10H_2O$, Borax (46); *P*

λ*	α	β	γ
589*D*	1.4463	1.4682	1.4712
	1.4468	1.4694	1.4724

λ	$\delta\beta_D$
486*F*	56
535Tl	25
671Li	−29

$\delta\alpha_D = 0.89\delta\beta_D$; $\delta\gamma_D = 0.97 \times \delta\beta_D$. $2V_D$ = 39° 14′ to 39° 36′.

* From (115).

216. $Na_2O.2Al_2O_3.Sb_2O_5$, Swedenborgite (2)

λ	ω	ε
486*F*	1.782_2	1.779_1
527*E*	1.777_5	1.774_8
589*D*	1.772_4	1.770_0
656*C*	1.769_6	1.766_8
687*B*	1.768_4	1.765_8

217. $NaAlSiO_4$ *ca.*, Nephelite

λ	ω	ε	Lit.
486*F* *ca.*	1.548_0	1.544_3	(189)
589*D*	1.541_7	1.538_2	(189)
589*D*	1.537*	1.533*	(24)
589*D*	1.537†	1.539†	(24)
656*C* *ca.*	1.5392	1.5357	(189)
759*A* *ca.*	1.5366	1.5332	(189)

* Pure $NaAlSiO_4$.

† Contains 35 % $CaAl_2Si_2O_8$.

218. $NaAlSi_3O_8$, Albite; feldspar, *cf.* 261 (67, 106, 133); *P*

λ	α	β	γ
589*D*	1.528_2	1.532_3	1.538_6

λ	$\delta\beta_D$	λ	$\delta\beta_D$
405Hg	138−	656*C*	−24+
434*G′*	104−	687*B*	−34
486*F*	58	706He	−39+
535Tl	27−	768*A′*	−54+

$\delta\alpha_D = 0.98_5\delta\beta_D$; $\delta\gamma_D = 1.02 \times \delta\beta_D$; $+2V_{G'} = 77.2°$; $+2V_C = 77°$.

220. $Na_2Al_2H_4Si_3O_{12}$ *ca.*, Natrolite (32, 148)

λ	α	β	γ
589*D*	1.475	1.479	1.489
	1.478	1.481	1.491

λ	$\delta\alpha_D$	$\delta\beta_D$	$\delta\gamma_D$
535Tl	25	25	28
671Li	−24	−26	−29

221. $Na_4Al_3Si_9O_{24}Cl$ *ca.*, Marialite (11, 58, 74, 114, 194); with 589*D*, $\omega = \epsilon = 1.53_3$; $\delta\omega_D = \delta\epsilon_D = \delta\epsilon_D$ of Meionite (162)

λ	ω	ε
589*D*	1.568*	1.545*

* 50 % Marialite + 50 % Meionite.

222. $BeNaPO_4$, Beryllonite (39); *cf.* (72)

λ	α	β	γ
535Tl	1.5544	1.560_4	1.563_6
589*D*	1.5520	1.557_9	1.560_8
671Li	1.5492	1.555_0	1.557_8

$-2V_{671} = 67° 2_2'$; $-2V_D = 67° 34'$; $-2V_{535} = 67° 5_0'$.

223. $BeNaHSi_3O_8$, Epididymite (70)

λ	α	β	γ
535Tl	1.5465	1.5466	1.5491
589*D*	1.5440	1.5441	1.5464
671Li	1.5416	1.5417	1.5438

224. $MgNa_2.2SO_4.4H_2O$, Blödite (192); *p*

λ	α	β	γ
535Tl	1.4843	1.4858	1.4888
589*D*	1.4825	1.4839	1.4866
671Li	1.4807	1.4820	1.4847

225. $Na_4Al_{16}B_6Si_{12}H_8O_{63}$, Na-tourmaline

Tourmaline is near $Na_4Al_{16}B_6Si_{12}H_8O_{63}$ and $Mg_{12}Al_{10}B_6Si_{12}H_6O_{63}$ (Mg-tourmaline), with various substitutions. Data read from curves (16, 57, 162, 172, 175, 240).

Na-tourmaline

λ	ω	ω − ε
589*D*	1.63_6	0.017_2
λ	$\delta\omega_C$	$\delta\epsilon_C$
486*F*	94	87

Mg-tourmaline

λ	ω	ω − ε
589*D*	1.63_3	0.019_5
λ	$\delta\omega_C$	$\delta\epsilon_C$
434*G′*	150	136+
486*F*	96	87
589*D*	29	26
656*C*	0	0

Either with *ca.* 7 % Fe_2O_3 + 8 % FeO

λ	ω	ε
589*D*	1.685	1.651
λ	$\delta\omega_C$	$\delta\epsilon_C$
486*F*	14_0	12_0

226. $CaNa_2.2CO_3.2H_2O$, Pirssonite (156)

λ	α	β	γ
535Tl	1.507_0*	1.512_0	1.579_1
589*D*	1.504_0	1.508_9	1.574_9
671Li	1.501_3*	1.506_1	1.571_2

* From β, γ and 2*V*.

227. Na, Ca, (Mn), Fe, Zr, etc. metasilicate, Eudialite (237)

λ	ω	ε
535Tl	1.6120	1.6142
589*D*	1.6084	1.6102
671Li	1.6042	1.6060

228. $4Na_2O.CaO.4Al_2O_3.2CO_2.9SiO_2.3H_2O$, Cancrinite (1)

λ	ω	ε
486*F*	1.531	1.507
589*D*	1.525	1.502
656*C*	1.522	1.500

229. $(NaAlSi_3O_8)_x + (CaAl_2Si_2O_8)_y$, Feldspars; *see* 261

Includes: Albite (218) (for which $y = 0$), Andesine (229), Anorthite (159) (for which $x = 0$), Labradorite (229), Oligoclase (229).

229.—(*Continued*)

Dispersion for the range 700 > λ > 500 is linear with respect to either average refractive index or molecular composition. Oligoclase (143, 202), andesine and labradorite (202).

For $x = 78$, $y = 22$, oligoclase (143):

Range of temp.	λ	$\tau\alpha$	$\tau\beta$	$\tau\gamma$
0 to 150°	480	0.3_5	0.4_4	0.3_9
	671	0.2_7	0.3_8	0.3_7
150 to 300°	480	0.4_7	0.6_0	0.5_8
	671	0.4_4	0.5_0	0.4_9

230. $Na_2Ca_2Al_6Si_9O_{30}.8H_2O$ *ca.*, Mesolite (76); becomes uniaxial near 35°C

λ	α	β	γ
535Tl	1.507_0	1.507_2	1.507_5
589*D*	1.504_8	1.505_0	1.505_3
671Li	1.501_9	1.502_1	1.502_4

231. $BaNa_4(Ti, Zr)O_2(Si_2O_5)_5$, Leucosphenite (70)

231.1. $KClO_4$ (133, 251); *P*

λ	α	β	γ
589*D*	1.472_8	1.473_6	1.476_8

λ	$\delta\beta_D$	λ	$\delta\beta_D$
404Hg	101	546Hg	15
434*G′*	76	656*C*	−18
486*F*	43	706He	−29

$\delta\alpha_D = \delta\beta_D$; $\delta\gamma_D = 1.03\delta\beta_D$; $2V_C = 50° 1_5'$; $2V_F = 48° 4_8'$

231.2. KIO_4 (133)

λ	ω	ε
434*G′*	1.6473	1.6804
436Hg	1.6468	1.6798+
486*F*	1.6346	1.6651
546Hg	1.6253	1.6535+
578Hg	1.6216	1.6492+
589*D*	1.6205	1.6479
656*C*	1.6151	1.6416

232. K_2SO_4 (133, 200, 203); *P*; *cf.* Fig. 1

λ	α	β	γ
589*D*	1.4934	1.4946	1.4973

λ	$\delta\beta_D$*	λ	$\delta\beta_D$*
405Hg	113+	656*C*	−19+
434*G′*	84	706He	−31
486*F*	47		

$\delta\alpha_D = \delta\beta_D = \delta\gamma_D$; $+2V_D = 67° 20'$. For all colors if 20° < *t* < 180°, $\tau\alpha = \tau\beta = -4._0$, $\tau\gamma = -5._0$ (203).

* (133).

233. $K_2S_2O_6$ (167); *P*

λ	ω	ε
405Hg	1.4662	1.5370
436Hg	1.4631	1.5309
492Hg	1.4594	1.5237
546Hg	1.4567	1.518(6)
579Hg	1.4554	1.516(4)
623Hg	1.4544	1.5140
691Hg	1.4527	1.5110

234. $K_2S_3O_6$ (129); *P*

λ	α	β	γ
436Hg	1.5040	1.5805	1.621
486*F*	1.4993*	1.5732*	1.612
546Hg	1.4954	1.5673	
589*D*	1.4934*	1.5641*	1.602
656*C*	1.4909	1.5607	
691Hg	1.4900†	1.5591	1.596

* Interpolated.

† Corrected.

235. K_2SeO_4 (205); *P*

λ	α	β	γ
486*F*	1.5421	1.5460	1.5518
589*D*	1.5352	1.5390	1.5446
656*C*	1.5325	1.5362	1.5418

For all colors if 20° < *t* < 50°, $\tau\alpha = -5$, $\tau\beta = -6$, $\tau\gamma = -7+$.

236. KNO_3, Niter (133); *P*; for soda niter, *v.* 191.1

λ	α	β	γ
405Hg	1.3384	1.5299	1.5304
436Hg	1.3368	1.5224	1.5229
486*F*	1.3347	1.5139	1.5144
546Hg	1.3330	1.5072+	1.5077
589*D*	1.3320	1.5038	1.5042+
656*C*	1.3310	1.4998	1.5002
706He		1.4975	1.4979
768*A′*		1.4951	1.4955

237. KH_2PO_4 (200); *cf.* Fig. 1

λ	ω	ε
486*F*	1.515_4	1.473_4
589*D*	1.509_5	1.468_4
656*C*	1.506_4	1.466_4

238. KH_2AsO_4 (200)

λ	ω	ε
486*F*	1.576_2	1.525_2
589*D*	1.567_4	1.517_9
656*C*	1.563_2	1.514_6

239. $KHCO_3$ (133); *P*; *cf.* Fig. 1

λ	α	β	γ
405Hg	1.387		
434*G′*	1.385	1.492	1.588
486*F*	1.383	1.487+	1.581
589*D*	1.380	1.482	1.573
656*C*	1.379	1.479+	1.569
768*A′*	1.377	1.476	1.564

240. KHC_2O_4 (Acid oxalate) (133); *P*; *cf.* Fig. 1

λ	α	β	γ
404Hg			1.6004
436Hg	1.3791	1.5665+	1.5933
486*F*	1.3762	1.5602	1.5849
589*D*	1.3728	1.5518	1.5743
656*C*	1.3716	1.5482+	1.5700
668He	1.3714	1.5476+	1.5694
706He		1.5458	1.5673

241. $KC_6H_5O_4S$ (*p*-Phenolsulfonate) (86); *p*

λ	α	β	γ
486*F*	1.583_4	1.622_2	1.711_4
589*D*	1.571_4	1.607_9	1.694_2
656*C*	1.567_2	1.603_3	1.687_9

242. $KC_6H_5O_4S.2H_2O$ (*o*-Phenolsulfonate) (86); *p*

λ	α	β	γ
486*F*	1.5362	1.5796	1.6636
589*D*	1.5265	1.5677	1.6467
656*C*	1.5228	1.5634	1.6410

243. $KC_6H_2(NO_2)_3O$ (Picrate) (15); *P*

λ	α	β	γ
486*F*	1.577		
502He	1.560		2.046
588He	1.527	1.903	1.952
656*C*	1.517	1.842	1.916
668He	1.516	1.835	1.912

244. $2(SbO.K.C_4H_4O_6).H_2O$ (Tartrate) (200); *p*

λ	α	β	γ
486*F*	1.6325	1.6497	1.6511
589*D*	1.6199	1.6360	1.6375
656*C*	1.6148	1.6306	1.6322

245. $K_2Zn(SO_4)_2.6H_2O$; *see* Table 2

246. $K_2Zn(SeO_4)_2.6H_2O$; *see* Table 2

247. $CdCl_2.2KCl$ (177)

λ	ω	ε
527*E ca.*	1.5965	1.5966
589*D*	1.5906	1.5907
687*B ca.*	1.5841	1.5842

248. $CuCl_2.2KCl.2H_2O$ (59); *P*

λ	ω	ε
405Hg	1.6957	1.6439
436Hg	1.6807	1.6346
492Hg	1.6636	1.6235
546Hg	1.6530	1.6162
578Hg	1.6485	1.6133
623Hg	1.6438	1.6097

249. $K_2Cu(SO_4)_2.6H_2O$, Cyanochroite; *see* Table 2

250. $K_2Cu(SeO_4)_2.6H_2O$; *see* Table 2

251. $K_2PtC_2O_4(NO_2)_2.H_2O$ (Platonitritooxalate) (53); *p*

λ	α	β	γ
535Tl	1.5579	1.6510	1.770
589*D*	1.5450	1.6414	1.760
671Li	1.5343	1.6319	1.748

252. $K_2Fe(SO_4)_2.6H_2O$; *see* Table 2

253. $K_2Fe(SeO_4)_2.6H_2O$; *see* Table 2

254. $K_3Fe(CN)_6$ (178)

λ	α	β	γ
589*D*	1.5660	1.5689	1.5831
687*B ca.*	1.5591	1.5615	1.5759

255. $K_2Co(SO_4)_2.6H_2O$; *see* Table 2

256. $K_2Co(SeO_4)_2.6H_2O$; *see* Table 2

257. $K_2Ni(SO_4)_2.6H_2O$; *see* Table 2

258. $K_2Ni(SeO_4)_2.6H_2O$; *see* Table 2

259. $K_6Cr_2(CN)_{12}$ (50); *p*

λ	α	β	γ
535Tl	1.5268	1.5292	1.5423
589*D*	1.5221	1.5244	1.5373
671Li	1.5176	1.5198	1.5324

260. $K_2UO_2(SO_4)_2.2H_2O$ (142.1); *P*

λ	α	β	γ
500	1.520	1.535	1.583
580	1.514	1.527	1.570
720	1.509	1.522	1.563

260.1. KBF_4, Avogadrite (245.1)

λ	α	β	γ
577	1.325	1.325	1.325
589*D*	1.324	1.325	1.325
677	1.323	1.324	

261. $KAlSi_3O_8$, Orthoclase; *P*; *see also* Microcline (261.1)

(A feldspar; others are: Albite (218), Andesine (229), Anorthite (159), Labradorite (229), Microcline (261.1), Oligoclase (229).

Orthoclase occurs in two optical orientations, crystal axis *a* is always near the α-axis, but crystal axis *b* is the γ-axis in normal orthoclase (adularia, etc.) and the β-axis in abnormal orthoclase. Here *b* and *e*, respectively, denote the γ and β indices for normal, and the β and γ indices for abnormal orthoclase. As temperature is increased, normal orthoclase ultimately becomes abnormal.

λ	α	*e*	*b*
589*D**	1.5177	1.5217	1.5231
	1.5170	1.5211	1.5208
589*D*†	1.518	1.522	1.524
	1.523	1.527	1.529

λ	δb_D‡	λ	δb_D‡
434*G′*	101	656*C*	−24
486*F*	57	719*a*	−41
535Tl	26		

$\delta\alpha_D = (0.98 \text{ to } 0.985)\delta b_D$; $\delta e_D = (1.005 \text{ to } 1.01)\delta b_D$

λ	τ_α	τ_e	τ_b
	−50° to 150° (232)		
535–671	0.30	0.48	0.20
	150° to 400° (232)		
535–671	0.51	0.61	0.51
	0° to 150° (143)		
480	0.30	0.45	0.20
671	0.24	0.40	0.17
	150° to 300° (143)		
480	0.60	0.70	0.50
671	0.50	0.62	0.37

* For pure; extrapolated from impure specimens.

† From (30, 106, 232).

‡ From (30, 106, 139, 143, 232).

261.1. $KAlSi_3O_8$, Microcline, a feldspar (57); *see also* Orthoclase (261)

λ	α	β	γ
589*D*	1.5188	1.5226	1.5253

λ	$\delta\beta_D$
535Tl	30
671Li	−30

$\delta\alpha_D = \delta\beta_D = \delta\gamma_D$.

262. $K_2O.Al_2O_3.4SiO_2$, Leucite (164); weak birefringence; *n* = mean index; 750° is above inversion temperature

λ	$n_{21°}$	$n_{750°}$
434*G′*	1.5188	1.5053
486*F*	1.5146	1.5009
589*D*	1.5088*	1.4947*
656*C*	1.5061	1.4921
719*a*	1.5046	1.4903

λ.......	434	687
Interval....	τn†	
21 to 425°...	−0.80	−0.70
425 to 585°...	−1.6	−1.5

* At 425, 585, and 660° n_D = 1.5058, 1.5033, 1.5000, respectively.

† Between 500 and 750° is irregular due to inversion.

263. $KH_2Al_3Si_3O_{12}$, Muscovite (mica) (112, 157, 172)

λ	α	β	γ
589*D*	1.551	1.580	1.585

Addition of 5% Fe‴ increases α, β, γ by 0.0018, 0.0024, 0.0026, respectively. For sample with *ca.* 2.5% Fe‴, $n_{535} - n_{671} = 0.006+$, whether *n* = α, β, or γ.

264. $K_2Mg(SO_4)_2.6H_2O$, Picromerite; *see* Table 2

265. $K_2Mg(SeO_4)_2.6H_2O$; *see* Table 2

266. $K_2Ca(SO_4)_2.H_2O$, Syngenite (72, 180); *P*; uniaxial for λ = 706 if *t* = 127°, for λ = 471 if *t* = 178°

λ	α	β	γ
589*D*	1.500+	1.517	1.518
λ	$\delta\alpha_D$	$\delta\beta_D$	$\delta\gamma_D$
471He	59	61	62
486*F*	49	50	51
502He	40	40+	41
706He	−31	−33	−36

If $10° < t < 130°$, $\tau_\alpha = \tau_\beta = -2.6$, $\tau_\gamma = -3.5$.

267. $K_2O.8CaO.16SiO_2.16H_2O$ *ca.*, Apophyllite (59)

λ	ω	ε
405Hg	1.5496	1.5496
436Hg	1.5456	1.5459
492Hg	1.5403	1.5410
546Hg	1.5366+	1.5376+
578Hg	1.5349	1.5360+
623Hg	1.5329+	1.5342
671	1.5311	1.5325+

267.—(*Continued*)

Range: Dispersion, several % (201); ω_D = 1.535 to 1.545; birefringence (231); $\omega_D - \epsilon_D$ = +0.0003 to −0.0025.

268. $LiKSO_4$ (241, 254); *p*

λ	ε	ω
486*F*	1.4759	1.4762
589*D*	1.4715	1.4721
656*C*	1.4697	1.4703

269. $LiKPt(CN)_4.3(?)H_2O$ (14); *see* Fig. 2

λ	α	β	γ
588He	1.6237	1.6278	2.292
656*C*	1.6183	1.6217	2.040
668He			2.014
706He			1.953

270. $NaKC_4H_4O_6.4H_2O$ (Tartrate) (222); *P*

λ	α	β	γ
434*G′*	1.5014	1.5028	1.5075
486*F*	1.4962	1.4979	1.5022
589*D*	1.4899	1.4917	1.4954
656*C*	1.4872	1.4890	1.4926

If $-70° < t < +40°$, $\tau_\alpha = -6.5$, $\tau_\beta = -6.1$ for all colors, and $\tau_\gamma = -6.8$ for blue and −6.2 for red.

271. $FeCl_2.3KCl.NaCl$, Rinneite (20)

λ	ω	ε
535Tl	1.5930	1.5939
589*D*	1.5886	1.5894
671Li	1.5836	1.5842

271.1. $RbClO_4$ (251); *P*

λ	α	β	γ
589*D*	1.4692	1.4701	1.4731
λ	$\delta\beta_D$\*	λ	$\delta\beta_D$\*
434*G′*	75	656*C*	−18

$\delta\alpha_D = \delta\beta_D$; $\delta\gamma_D = 1.01\,\delta\beta_D$; $2V_C = 55°\ 12'$; $2V_F = 54°\ 33'$.

* Curves, *see* 231.1.

272. Rb_2SO_4 (203); *P*

λ	α	β	γ
486*F*	1.5181	1.5183	1.5194
589*D*	1.5131	1.5133	1.5144
656*C*	1.5112	1.5113	1.5124

If $60° < t < 180°$, for all colors, $\tau_\alpha = -4$, $\tau_\beta = \tau_\gamma = -3+$.

273. $Rb_2S_2O_6$ (62); *P*

λ	ω	ε	(ε − ω)*
405Hg	1.4672	1.528	0.0598
436Hg	1.4642	1.525	0.0572
486*F*	1.4613	1.5153	0.0541
589*D*	1.4565	1.5068	0.0505
656*C*	1.4544	1.5034	0.0491
691Hg	1.4534	1.5017	0.0485

* By interference.

274. Rb_2SeO_4 (205); *P*

λ	α	β	γ
486*F*	1.5586	1.5609	1.5655
589*D*	1.5515	1.5537	1.5582
656*C*	1.5487	1.5509	1.5554

If $20° < t < 80°$, for all colors, $\tau_\alpha = -4+$, $\tau_\beta = -5$, $\tau_\gamma = -6+$.

275. $Rb_2Zn(SO_4)_2.6H_2O$; *see* Table 2

276. $Rb_2Zn(SeO_4)_2.6H_2O$; *see* Table 2

277. $Rb_2Cd(SO_4)_2.6H_2O$; *see* Table 2

278. $Rb_2Cu(SO_4)_2.6H_2O$; *see* Table 2

279. $Rb_2Cu(SeO_4)_2.6H_2O$; *see* Table 2

280. $Rb_2Mn(SO_4)_2.6H_2O$; *see* Table 2

281. $Rb_2Mn(SeO_4)_2.6H_2O$; *see* Table 2

282. $Rb_2Fe(SO_4)_2.6H_2O$; *see* Table 2

283. $Rb_2Fe(SeO_4)_2.6H_2O$; *see* Table 2

284. $Rb_2Co(SO_4)_2.6H_2O$; *see* Table 2

285. $Rb_2Co(SeO_4)_2.6H_2O$; *see* Table 2

286. $Rb_2Ni(SO_4)_2.6H_2O$; *see* Table 2

287. $Rb_2Ni(SeO_4)_2.6H_2O$; *see* Table 2

288. $Rb_2Mg(SO_4)_2.6H_2O$; *see* Table 2

289. $Rb_2Mg(SeO_4)_2.6H_2O$; *see* Table 2

290. $Rb_2Mg(CrO_4)_2.6H_2O$; *see* Table 2

291. $RbLiPt(CN)_4.3(?)H_2O$ (14)

λ	α	β	γ
588He	1.620_4	1.623_4	1.931
656*C*	1.615_3	1.617_6	1.827
668He			1.815

291.1. $CsClO_4$ (251); *P*

λ	α	β	γ
589*D*	1.475_2	1.478_8	1.480_4
λ	$\delta_{\beta D}$*	λ	$\delta_{\beta D}$*
434*G'*	80+	656*C*	−19

$\delta\alpha_D = 0.98\delta\beta_D$; $\delta\gamma_D = 1.02 \times \delta\beta_D$; $-2V_C = -2V_F = 62._5°$.

* Curves, *see* 231.1.

292. Cs_2SO_4 (203); *P*

λ	α	β	γ
486*F*	1.5660	1.5706	1.5725
589*D*	1.5598	1.5644	1.5662
656*C*	1.5573	1.5619	1.5637

292.—(*Continued*)

For all colors, if $20° < t < 180°$, $\tau_\alpha = -4$, $\tau_\beta = -3+$, $\tau_\gamma = -3$.

293. $Cs_2S_2O_6$ (61); *P*

λ	ω	ε
405Hg	1.536_6	1.564_0
436Hg	1.5328	1.5583
486*F*	1.5285	1.5518
492Hg	1.5282	1.5513
589*D*	1.5230	1.5438
656*C*	1.5207	1.5405
719*a*	1.5191	1.5382

294. Cs_2SeO_4 (205); *P*; *cf.* Fig. 1

λ	α	β	γ
486*F*	1.6070	1.6080	1.6084
589*D*	1.5989	1.5999	1.6003
656*C*	1.5955	1.5965	1.5969

For all colors, if $20° < t < 80°$, $\tau_\alpha = -7+$, $\tau_\beta = \tau_\gamma = -6$.

295. $Cs_3Tl_2Cl_9$ (155)

λ	ω	ε
535Tl	1.792	1.786
589*D*	1.784	1.774
671Li	1.772	1.762

296. $Cs_2Zn(SO_4)_2.6H_2O$; *see* Table 2

297. $Cs_2Zn(SeO_4)_2.6H_2O$; *see* Table 2

298. $Cs_2Cd(SO_4)_2.6H_2O$; *see* Table 2

299. $Cs_2Cu(SO_4)_2.6H_2O$; *see* Table 2

300. $Cs_2Cu(SeO_4)_2.6H_2O$; *see* Table 2

301. $Cs_2Mn(SO_4)_2.6H_2O$; *see* Table 2

302. $Cs_2Mn(SeO_4)_2.6H_2O$; *see* Table 2

303. $Cs_2Fe(SO_4)_2.6H_2O$; *see* Table 2

304. $Cs_2Fe(SeO_4)_2.6H_2O$; *see* Table 2

305. $Cs_2Co(SO_4)_2.6H_2O$; *see* Table 2

306. $Cs_2Co(SeO_4)_2.6H_2O$; *see* Table 2

307. $Cs_2Ni(SO_4)_2.6H_2O$; *see* Table 2

308. $Cs_2Ni(SeO_4)_2.6H_2O$; *see* Table 2

308.1. $Cs_2UO_2Cl_4$ (142.1)

309. $Cs_2Mg(SO_4)_2.6H_2O$; *see* Table 2

310. $Cs_2Mg(SeO_4)_2.6H_2O$; *see* Table 2

311. $Cs_2Mg(CrO_4)_2.6H_2O$; *see* Table 2

II. ℭ-Table; Organic Compounds; ℭ-Arrangement; *v.* Vol. III, p. viii

CH_2I_2, Methylene iodide, liquid; for comparison only *see* Fig. 1

CH_5AsO_3, Methylarsenic acid (53)

λ	α	β	γ
535Tl	1.5105	1.5490	1.5499
589*D*	1.5074	1.5457	1.5463
671Li	1.5037	1.5415	1.5417

$C_2H_4N_4$, Dicyandiamide (86)

486*F*	1.532_1	1.557_9	1.870
589*D*	1.521_2	1.549_8	1.847
656*C*	1.517_7	1.545_4	1.835

$C_2H_5NO_2$, Glycocoll (117)

486*F*	1.5C65	1.6256	1.6758
687*B*	1.4985	1.6115	1.6588

$C_2H_8N_2O_4.H_2O$, Ammonium oxalate (133)

405Hg	1.4503	1.5658	1.6212
436Hg	1.4472	1.5606	1.6139
502He	1.4427	1.5528	1.6033
546Hg	1.4403	1.5489	1.5983
588He	1.4387	1.5458	1.5944
668He	1.4362	1.5417	1.5889
706He			1.5868

$C_3H_6N_6$, Melamine (86)

486*F*	1.4992	1.7656	1.902_0
589*D*	1.4906	1.7429	1.872_1
656*C*	1.4876	1.7340	1.860_8

$C_8H_6N_6O_6$, Trimethylenetrinitroamine (197)

447He	1.597	1.620+	1.624+
471He	1.592+	1.614+	1.618+
486*F*	1.589+	1.611+	1.615+
535Tl	1.582+	1.603	1.608
589*D*	1.577_5	1.596_6	1.601_5
656*C*	1.573	1.591+	1.597

$C_3H_{12}N_6O_3$, Guanidine carbonate (18, 120)

λ	ω	ε
535Tl	1.503_5*	1.493_0*
589*D*	1.500_0*	1.489_5*
589*D*	1.499_0	1.496_2
671Li	1.495_4*	1.484_9*

* Recalculated from (18).

$C_4H_2O_3$, Maleic anhydride (138)

λ	α	β	γ
589*D*	1.4429	1.4781	1.638_4
671Li	1.4397	1.4745	1.631_3

$C_4H_4INO_2$, Iodosuccinimide (219)

λ	ω	ε
486*F*	1.712_9	1.690_9
535Tl	1.703_3	1.679_7
589*D*	1.696_5	1.672_6
656*C*	1.690_3	1.665_2
671Li	1.689_6	1.664_5

$C_4H_6O_4$, Succinic acid (86)

λ	α	β	γ
486*F*	1.455_8	1.541_0	1.620_4
589*D*	1.450_3	1.533_8	1.610_0
656*C*	1.448_6	1.531_5	1.606_2

$C_4H_6O_4$, Dimethyl oxalate (86)

486*F*	1.426_7	1.470+	1.563
589*D*	1.417_7	1.461+	1.552
656*C*	1.416	1.460+	1.550

$C_4H_8Cl_2O_2$, Erythritoldichlorohydrin (52)

λ	ω	ε
535Tl	1.5568	1.5175
589*D*	1.5535	1.5149
671Li	1.5497	1.5119

$C_4H_8N_2O_3.H_2O$, Asparagine (178)

λ	α	β	γ
527*E ca.*	1.5513	1.5845	1.6238
589*D*	1.5476	1.5800	1.6190
687*B ca.*	1.5438	1.5752	1.6139

$C_4H_9NO_6$, Ammonium hydrogen tartrate (200)

486*F*	1.52_8	1.56_9	1.60_0
589*D*	1.51_9	1.56_1	1.59_1
656*C*	1.51_7	1.55_8	1.58_6

$C_5H_{10}O_5$, *l*-α-Arabinose (234)

589*D*	1.551	1.567	1.571

Dispersion same as for *d*-α-Lyxose.

$C_5H_{10}O_5$, *d*-β-Arabinose (234)

589*D*	1.555	1.573	1.577

Dispersion is *ca.* 15 % > that for *d*-α-Lyxose.

$C_5H_{10}O_5$, *d*-α-Lyxose (234)

450	1.541	1.550	1.559
500	1.537	1.546	1.554+
589*D*	1.532	1.541	1.549
650	1.530	1.538+	1.547

$C_5H_{10}O_5$, *d*-α-Xylose (234)

589*D*	1.517	1.544	1.546

Dispersion is *ca.* 10 % < that for *d*-α-Lyxose.

$C_6H_6ClNO_2$, Picolinic acid hydrochloride (116)

535Tl	1.4514	1.713	1.764
589*D*	1.448_2	1.705	1.754
671Li	1.443_8	1.695	1.741

$C_6H_6N_4O_7$, Ammonium picrate

λ	α	β	γ
486	1.543		
513	1.528	1.960	2.004
528	1.522	1.944	1.961
541	1.518	1.933*	1.933*
588	1.508+	1.872	1.908
668	1.499	1.81+	1.880
Lit.	(15)	(129)	(129)

* β and γ interchange orientations.

$C_6H_6O_2$, *o*-Dihydroxybenzene (86)

486*F*	1.620_4	1.631_4	1.753_6
589*D*	1.604_4	1.613_9	1.733_6
656*C*	1.598_0	1.607_3	1.725_5

$C_6H_6O_2$, Resorcinol (86)

486*F*	1.590_1	1.637_2	1.644_9
589*D*	1.578_1	1.619_7	1.627_3
656*C*	1.572_5	1.613_2	1.620_8

$C_6H_6O_2$, Hydroquinol (86)

λ	ω	ε
486*F*	1.647_9	1.642_0
589*D*	1.632_5	1.626_2
656*C*	1.626_0	1.619_5

$C_6H_8O_7.H_2O$, Citric acid (177)

λ	α	β	γ
527*E ca.*	1.4967	1.5012	1.5123
589*D*	1.4932	1.4977	1.5089
687*B ca.*	1.4896	1.4943	1.5054

$C_6H_{12}O_5.H_2O$, Rhamnose (55)

λ	α	β	γ
434*G′*	1.5337_9	1.5422_2	1.5444_6
486*F*	1.5289_2	1.5372_4	1.5396_0
535Tl	1.5256_3	1.5338_8	1.5363_1
589*D*	1.5229_3	1.5310_6	1.5336_0
656*C*	1.5203_4	1.5283_8	1.5310_0
671Li	1.5198_6	1.5278_8	1.5305_2

$C_7H_6N_2O_4$, 2, 4-Dinitrotoluene (86)

486*F*	1.452+	1.677_1	1.788_4
589*D*	1.442+	1.661_9	1.755_6
656*C*	1.439+	1.656_7	1.744_0

$C_7H_6N_2O_4$, 2, 6-Dinitrotoluene (86)

486*F*	1.487_5	1.689_8	1.762_1
589*D*	1.478_8	1.669_4	1.734_0
656*C*	1.475_5	1.622_5	1.724_5

$C_7H_{10}N_2O_7$, Dimethyl monoureidodihydroxysuccinate (135)

$C_7H_{10}N_4O_5$, Isohydroxy-3, 7-dimethyluric acid (199)

λ	α	β	γ
535Tl	1.503	1.521	1.679
589*D*	1.495	1.513	1.672
671Li	1.491	1.509	1.665

$C_7H_{13}NO_5$, Ammonium shikimate (66)

486*F*	1.476	1.595	1.668
589*D*	1.470	1.586	1.652
656*C*	1.468	1.581	1.646

$C_7H_{14}O_5$, α-Methylrhamnoside (163)

535Tl	1.539	1.543	1.543
589*D*	1.536	1.540	1.541
671Li	1.534	1.538	1.538

$C_7H_{14}O_6$, α-Methylgalactoside (163)

535Tl	1.524	1.526	1.532
589*D*	1.521	1.523	1.529
671Li	1.520	1.522	1.527

$C_7H_{14}O_6$, β-Methyl-*d*-glucoside (198)

λ	ω	ε
535Tl	1.534	1.520
589*D*	1.529	1.513
671Li	1.527	1.511

$C_7H_{14}O_6$, α-Methylmannoside (198)

λ	α	β	γ
535Tl	1.531	1.533	1.539
589*D*	1.528	1.529	1.537
671Li	1.527	1.528	1.532

$C_8H_{17}ClN_2$, Isobutyraldazine chlorohydrate (142)

$C_9H_6O_2$, α, γ-Diketohydrindene (153)

λ	486*F*	589*D*	656*C*
ω	1.640	1.61_9	1.613; ε > ω

C_9H_9NO, 2-(α)-Ketotetrahydroquinoline (hydrocarbostyril) (8)

λ	α	β	γ
535Tl	1.4821		1.8257
589*D*	1.4792	1.7095	1.8102

$C_9H_{12}N_4O_3$, Tetramethyluric acid (163)

λ	α	β	γ
535Tl	1.545	1.616	1.764
589*D*	1.538	1.609	1.754
671Li	1.532	1.604	1.750

$C_9H_{14}N_2O_7$, Diethyl monoureidodihydroxysuccinate (135)

535Tl	1.539	1.557	1.579
589*D*	1.537	1.554	1.577
671Li	1.535	1.553	1.576

$C_{10}H_4Cl_6O$, Hexachloro-β-ketohydronaphthalene (99)

535Tl	1.642_9	1.646	1.65_1
589*D*	1.637_5	1.643	1.64_9
671Li	1.632_0	1.639	1.64_7

$C_{10}H_7Br$, Bromonaphthalene*

*Liquid; for comparison only; *see* Fig. 1.

$C_{10}H_{20}O_2.H_2O$, *cis*-Terpine hydrate (5)

λ	α	β	γ
535Tl	1.507_3	1.514_8	1.527_2
589*D*	1.504_9	1.512_4	1.524_3
671Li	1.502_4	1.509_3	1.521_1

$C_{11}H_{21}NO_3$, *N*-Methyl-2, 2, 6, 6-tetramethyl-4-hydroxypiperidinecarboxylic acid (198)

535Tl	1.541	1.551_2	1.559_1
589*D*	1.533	1.545_9	1.556_2
671Li	1.527	1.541_2	1.552_4

$C_{12}H_{20}O$, Matico camphor (89)

λ	ω	ε
535Tl	1.548_8	1.547_6
589*D*	1.544_7	1.543_6
671Li	1.541_5	1.540_4

$C_{12}H_{22}O_{11}$, Saccharose (cane sugar) (133)

λ	α	β	γ
405Hg	1.5524	1.5803	1.5858
436Hg	1.5484	1.5762+	1.5816+
502He	1.5425	1.5702	1.5756
546Hg	1.5397+	1.5673	1.5727
588He	1.5377	1.5652	1.5706
706He	1.5336	1.5610+	1.5664

$C_{14}H_{12}O$, Phenyl *p*-tolyl ketone (19)

λ	ω	ε
535Tl	1.725	1.569
589*D*	1.717	1.563
671Li	1.707	1.556

$C_{14}H_{12}O_3$, Amyrolin (168*)

λ	α	β	γ
405Hg	1.4838	1.8558	2.1989
436Hg	1.4778	1.8164	2.0986
492Hg	1.4713	1.7791	2.0126
546Hg	1.4669	1.7588	1.9684
579Hg	1.4650	1.7504	1.9505
589*D*	1.4645	1.7480	1.9458
623Hg	1.4630	1.7412	1.9326
691Hg	1.4604†	1.7323	1.9138

* Accuracy of data cannot be closely estimated. † In original, 1.4589.

$C_{15}H_{12}O_2$, Dibenzoylmethane (enol form) (166)

λ	α	β	γ
420 *ca.*	1.7354	1.8800	2.3960†
440 *ca.*	1.7206	1.7919	2.2356†
480 *ca.*	1.7031	1.7264	2.0989†
526 *ca.**	1.6913	1.6913	2.0242†
580 *ca.*	1.6817‡	1.6672§	1.9746†
720 *ca.*	1.6697‡	1.6401§	1.9185†

* α and β interchange as λ passes through 526. † Quite uncertain. ‡ β. § α.

$C_{16}H_{10}O_3$, Diphenylmaleic anhydride (42)

$C_{16}H_{14}O$, Benzylidene *p*-tolyl ketone (181)

λ	α	β	γ
535Tl	1.634+	1.653	1.935
589*D*	1.620+	1.642+	1.909
671Li	1.607+	1.634	1.881

$C_{16}H_{14}O_2$, *p*-Toluylacetophenone (enol form) (166)

438	1.690	1.805	2.36
459.3	1.679	1.758	2.23
500	1.663	1.711	2.12
552	1.650	1.680	2.03
646.5	1.638	1.652	1.95

$C_{17}H_{23}NO_4$, Menthyl *o*-nitrobenzoate (79)

535Tl	1.5003	>1.505	1.5781
589*D*	1.4966	1.5015*	1.5722
671Li	1.4927	<1.498	1.5659

* Recalculated.

$C_{17}H_{24}O_{10}$, Ethyl tetraacetylquinate (87)

535Tl	1.493_1	1.507_1*	1.517_2
589*D*	1.489_7	1.503_7*	1.513_8
671Li	1.486_9	1.501_0*	1.511_1

* Recalculated.

$C_{18}H_{15}BiCl_2$, Triphenylbismuth dichloride (81)

436Hg	1.785	1.788+	1.848
546Hg	1.744+	1.745	1.803
589*D*	1.734*	1.735*	1.795

* α and β interchange between λ = 589 and λ = 546.

$C_{18}H_{21}NO_3.H_2O$, Codeine (86)

486*F*	1.550_7	1.651_4	
589*D*	1.542_8	1.635_5	1.683_8
656*C*	1.540_2	1.628_5	1.673_0

$C_{18}H_{21}NO_3$, Isocodeine (86)

λ	α	β	γ
486*F*	1.614_9	1.655_7	
589*D*	1.607_0	1.642_2	1.675_7
656*C*	1.602_6	1.636_4	1.669_4

$C_{18}H_{21}NO_3$, Pseudocodeine (86)

$C_{18}H_{32}O_{16}.2H_2O$, Melezitose dihydrate (235)

λ	α	β	γ
589*D*	1.540	1.548	1.550

Dispersions = those of β-Arabinose, $C_5H_{10}O_5$.

$C_{21}H_{19}BrN_2$, Amarine hydrobromide (193)

λ	ω	ε
535Tl	1.63_8	1.77_2
589*D*	1.63_0	1.75_7
671Li	1.62_8	1.75_1

$C_{21}H_{19}ClN_2$, Amarine hydrochloride (193)

535Tl	1.62_8	1.75_8
589*D*	1.62_3	1.74_7
671Li	1.61_4	(?)

$C_{21}H_{36}O_2$, *d*-Bornylmethylene ether (239)

λ	α	β	γ
486*F*	1.5442	1.5490	1.5561
535Tl	1.5401	1.5449	1.5520
589*D*	1.5375	1.5422	1.5493
656*C*	1.5348	1.5395	1.5464
671Li	1.5343	1.5390	1.5459

$C_{22}H_{38}O_2S_3$, Menthylxanthogenthic thioanhydride (195)

535Tl	1.530	1.60_0	1.67_2
589*D*	1.52_6	1.59_7	1.66_5
671Li	1.51_4	1.59_2	1.65_2

$C_{23}H_{19}NO_5$, *O*, 4-Methylbenzoyl-*N*-4-methoxybenzoylbenzhydroxamic acid (198)

535Tl	1.552	1.644	1.830
589*D*	1.549	1.638	1.815
671Li	1.548	1.632	1.794

TABLE 2, *see p. 31–32*

TABLE 3.—WAVE-LENGTHS CORRESPONDING TO VARIOUS SYMBOLS

Unit of λ = 10 Å = 1 mμ = 10^{-7} cm

Symbol	λ	Symbol	λ	Symbol	λ
226Cd	226.503	455Ba	455.40	578Hg	579.07
231Cd	231.288	468Cd	467.82		576.96
257Cd	257.304	471He	471.31	588He	587.56
275Cd	274.867	480Cd	479.99	589*D*	589.00Na
340Cd	340.365	486*F*	486.13Hβ		589.59Na
347Cd	346.69	492Hg	491.60	623Hg	623.44
361Cd	361.2_5	492He	492.19	644Cd	643.85
393*K*	393.37Ca	502He	501.57	656*C*	656.28H_α
397*H*	396.85Ca	508Cd	508.58	668He	667.81
410*h*	410.17Hδ	527*E*	526.95Fe	671Li	670.79
405Hg	404.66		527.03Ca	691Hg	690.75
431*G*	430.77Ca		527.04Fe	687*B*	687.1 *ca.*
	430.79Fe	535Tl	535.05	706He	706.52
434*G′*	434.05Hγ	538Cd	537.89	719*a*	718.9 *ca.*
436Hg	435.83	546Hg	546.07	760*A*	759.41
447He	447.15	561Pb	560.88		762.13
				768*A′*	768.19K

TABLE 2.—REFRACTION OF PURE SULFATES, SELENATES AND CHROMATES OF THE TYPE R″R$_2$(SO$_4$)$_2$.6H$_2$O

The data relating to dispersion (in air at room temperature) have been determined from curves that take account of the similarities of all these sulfates and selenates. In most cases, approximate measurements (204) have been made for $\lambda = G' = 434\text{m}\mu$, but, excepting the Tl-salts, more accurate values can be derived from the relations: $(\beta_{G'} - \beta_F) = 0.76(\beta_F - \beta_C)$ for the sulfates, and $(\beta_{G'} - \beta_F) = 0.79(\beta_F - \beta_C)$ for the selenates. For a few of the salts, more complete dispersion data ($\delta\beta_D$, etc.) are given at the end of the Table, where $10^{-4}\delta\beta_D = \beta_\lambda - \beta_D$. The apparent uncertainties in the less accurate values of $2V_C$ and of $2(V_F - V_C)$ are indicated by *a* (=7′), *b* (=12′), *c* (=25′), and *d* (=60′). $10^{-5}\tau_{\beta D} = d\beta_D/dt$, if $10° < t < 80°$; $(\alpha_F - \alpha_C) = (\beta_F - \beta_C + \Delta\alpha)$; $(\gamma_F - \gamma_C) = (\beta_F - \beta_C + \Delta\gamma)$. For more exact wave-lengths corresponding to symbols for λ, *see* Table 3, p. 30. Unit of $\Delta\alpha$, $\Delta\gamma$, $(\beta_D - \beta_C)$, and $(\beta_F - \beta_D) = 10^{-4}$; of $\lambda = 10$ Å $= 1\text{m}\mu = 10^{-7}$ cm.

R″	R	α_D	β_D	γ_D	Δ_α	$\beta_D - \beta_C$	$\beta_F - \beta_D$	$\Delta\gamma$	$2V_C$	$2(V_F - V_C)$	$\tau\alpha_D$	$\tau\beta_D$	$\tau\gamma_D$	Lit.
R″ R$_2$(SO$_4$)$_2$.6H$_2$O														
Zn	K	1.4775	1.4834	1.4968	−2	24	54	4	68° 16′	− 0° 7′		−3+		(151, 204)
	Rb	1.4833	1.4883	1.4975	−2	24	55	3	73 40^b	− 0 22^b		−2+		(152, 204)
	Cs	1.5021	1.5049	1.5094	−1	25	57	2	74 27^b	− 0 54^b		−3		(151, 204)
	NH$_4$	1.4889	1.4932	1.499$_4$	−2	26	60	2	78 58	+ 0 5	−2+	−3	−4	(151, 209)
	Tl	1.5933	1.6093	1.6170	−9	47	111	12	−67 54^c	+ 2 12^c				(133, 152, 212)
Cd	Rb	1.4799	1.4849	1.495$_0$	−2	24	58	4	72 21^c	+ 0 2^c‖				(204)
	Cs	1.497$_5$	1.500$_0$	1.506$_2$	−2	25	59	4	68 2^b	− 0 34				(204)
	NH$_4$	1.484$_7$	1.488$_7$	1.495$_9$	−1	26	61	2	72 46^b	+ 0 15				(214)
Cu	K	1.483$_6$	1.4864	1.502$_0$	−3	26	58	4	46 6^b	+ 1 27^c		−4		(204)
	Rb	1.488$_6$	1.490$_6$	1.503$_5$	−2	26	59	5	44 29^b	+ 0 46		−3		(152, 204)
	Cs	1.504$_8$	1.5061	1.515$_3$	−1	26	61	2	43 9^b	+ 0 54		−3		(204)
	NH$_4$	1.491$_0$	1.500$_7$	1.505$_4$	−6	27	63	−1	−68 57^b	− 2 0^b	−1	−4	−5	(133, 214)
	Tl**	1.600	1.610	1.619	−2	4$_6$	12$_6$	2	−85 21	− 0 19				(252)
Mn	Rb	1.4766	1.4808	1.4908	−2	23	54	4	67 8	− 0 13		−3+		(152, 204)
	Cs	1.4946	1.496$_6$	1.5025	−1	25	58	2	60 7	− 0 29		−3+		(204)
	NH$_4$	1.480$_1$	1.484$_0$	1.491$_3$	0	25	58	1	69 46	+ 0 16	−3+	−3+	−3+	(214)
	Tl**	1.586	1.600	1.608	(?)	3$_6$(?)	11$_0$	(?)	−71 16	0 43				(252)
Fe	K	1.4759	1.4821	1.4969	−2	24	55	4	67 2^b	+ 0 17		−2+		(204)
	Rb	1.4814	1.4873	1.4978	−2	24	56	3	73 23	− 0 10		−3+		(152, 204)
	Cs	1.5003	1.5035	1.509$_4$	−1	25	58	2	75 0^b	− 0 2$_9^a$		−3+		(204)
	NH$_4$	1.487$_0$	1.491$_5$	1.499$_1$	−1	25	58	2	76 18	+ 0 15	*	−3+	*	(213)
	Tl**	1.592$_9$	1.609$_3$	1.616$_2$	(?)	4$_5$	11$_6$	(?)	−68 46	1 13				(252)
Co	K	1.480+	1.486+	1.500+	−2	24	54	4	68 39^c	+ 0 9		−4		(133, 204)
	Rb	1.486	1.491+	1.501+	−2	24	53	3	75 14^b	− 0 1$_1^a$		−3+		(152, 204)
	Cs	1.505+	1.508+	1.513+	−1	25	56	2	81 40^b	− 0 1$_8^a$		−3+		(204)
	NH$_4$	1.490$_2$	1.495$_3$	1.503$_2$	−2	26	60	3	82 2^b	+ 0 25	−4	−4+	−5	(133, 214)
	Tl	1.600$_9$	1.617$_6$	1.623$_8$	(?)	4$_8$	11$_7$	(?)	−66 6^b	+ 2 0^c				(219)
Ni	K	1.483$_6$	1.491$_6$	1.505$_1$	−3	24	55	4	75 19	− 0 10		−2+		(204)
	Rb	1.489$_5$	1.496$_3$	1.505$_4$	−2	24	56	3	82 4^b	− 0 1$_6^a$		−3		(152, 204)
	Cs	1.508$_7$	1.512$_9$	1.516$_2$	−1	25	58	1	−87 17	+ 0 23		−3		(204)
	NH$_4$	1.494$_9$	1.500$_7$	1.508$_1$	−3	26	60	3	86 28	+ 0 15	−3+	−3+	−4	(133, 214)
	Tl	1.602$_5$	1.618$_4$	1.625$_2$	−4	49	116	8	−60 0^c	+ 2 12^c				(133, 219)
Mg	K	1.4607	1.4629	1.475$_5$	−1	22	51	4	48 0^b	− 0 19^b		−4		(204)
	Rb	1.4671	1.4689	1.4780	−0.5	22	52	2	49 2	− 0 52		−2+		(152, 204)
	Cs	1.485$_7$	1.485$_8$	1.4916	+0.5	24	55	1	18 0^c	− 6 45^c		−3		(204)
	NH$_4$	1.4716	1.473$_0$	1.478$_6$	−0	25	56	1	51 18	− 0 4$_2^b$	−3†	−3+†	−4†	(209)
	Tl**	1.570$_5$	1.588$_4$	1.594$_9$	−6	46	108	4	−74 42	0 52				(252)
R″ R$_2$(SeO$_4$)$_2$.6H$_2$O														
Zn	K	1.512	1.518	1.533+	−3	31	70	8	66 13	+ 0 7		−4+		(206)
	Rb	1.516$_2$	1.522	1.533	−2	31	71	6	75 14^c	− 0 19		−4		(206)
	Cs	1.532+	1.536$_2$	1.541	−0	31	73	4	83 30	− 0 16^b		−3+		(206)
	NH$_4$	1.524$_0$	1.530$_0$	1.538$_5$	−2	33	78	2	82 5	+ 0 5	−2§	−2+	−3	(209)
	Tl**	1.641	1.654	1.661	(?)	5$_8$	16$_7$(?)	(?)	−68 15	1 15				(253)
Cd	NH$_4$	1.520$_6$	1.526$_0$	1.535$_2$	0	33	78	0	76 11^c	+ 0 49^c				(217)
Cu	K	1.510$_1$	1.522$_8$	1.534$_9$	−5	32	76	1	88 46^b	− 1 10^c		−3+		(218)
	Rb	1.515$_3$	1.518$_3$	1.531$_8$	−3	32	75	6	53 0^b	+ 0 43^b		−3		(218)
	Cs	1.528$_2$	1.529$_8$	1.539$_4$	−0	32	75	1	48 20^b	+ 0 22^b		−2+		(218)
	NH$_4$	1.520$_1$	1.534$_4$	1.538$_7$	−2	34	80	2	−55 42	− 1 54^b		−3		(218)
	Tl**	1.640	1.656+	1.672	−7	54	14$_4$	7	−85 13	− 0 17				(253)
Mn	Rb	1.509$_4$	1.514$_0$	1.525$_8$	−1	31	71	7	66 5^b	− 0 13		−2+		(218)
	Cs	1.525$_0$	1.527$_9$	1.533$_8$	+1	31	74	6	69 1^b	− 0 56	−2	−2+	−3	(217, 218)
	NH$_4$	1.516$_0$	1.520$_2$	1.528$_8$	−2	32	75	4	70 1$_8^b$	+ 0 16		−2		(218)
	Tl**	1.628	1.643	1.653	−6	5$_9$	15$_0$	6	−72 4	1 28				(253)
Fe	K	1.509$_5$	1.518$_2$	1.534$_5$	−3	32	72	6	64 1$_2^a$	+ 0 24				(218)
	Rb	1.513$_3$	1.520$_0$	1.532$_8$	−3	31	72	6	73 24	− 0 8	−3	−3+	−4	(218)
	Cs	1.530$_6$	1.535$_2$	1.541$_4$	−2	32	74	2	82 56^b	− 0 36^a		−2+		(218)
	NH$_4$	1.521$_6$	1.528$_0$	1.538$_1$	−1	33	76	1	77 37	+ 0 17	−2+	−3	−3+	(216, 218)
	Tl**	1.635$_2$	1.651$_4$	1.658$_9$	−3	5$_5$	14$_8$	3	−69 5	1 40				(253)
Co	K	1.515$_8$	1.521$_8$	1.538$_0$	−2	32	74	5	62 13	+ 0 3$_0^b$		−4		(218)
	Rb	1.519$_9$	1.525$_6$	1.536$_9$	−2	32	76	4	73 41^b	− 0 2$_0^b$		−4		(218)
	Cs	1.535$_4$	1.539$_9$	1.545$_3$	−2	33	77	4	87 18^b	− 1 1$_5^c$		−3		(218)
	NH$_4$	1.526$_1$	1.532$_7$	1.541$_7$	−2	33	77	4	82 6	+ 0 3$_0^b$		−2		(218)
	Tl**	1.644	1.653	1.659	(?)	4$_0$(?)	11$_1$(?)	(?)	−66 15	1 21				(253)
Ni	K	1.518$_1$	1.527$_2$	1.542$_7$	−3	33	76	6	72 45	+ 0 11^a		−3+		(218)
	Rb	1.519$_8$	1.529$_1$	1.539$_0$	−3	32	73	4	82 22	− 0 24^a		−3		(218)
	Cs	1.539$_5$	1.545$_0$	1.548$_9$	−2	33	76	3	−82 43^b	+ 1 0^b	−2+	−3	−3+	(215, 218)
	NH$_4$	1.528$_5$	1.537$_0$	1.546$_0$	−2	33	78	2	86 19	+ 0 10		−3+		(218)

TABLE 2.—(*Continued*)

R''	R	α_D	β_D	γ_D	$\Delta\alpha$	$\beta_D - \beta_C$	$\beta_F - \beta_D$	$\Delta\gamma$	$2V_C$	$2(V_F - V_C)$	$\tau\alpha D$	$\tau\beta D$	$\tau\gamma D$	Lit.
Ni	Tl**	1.638	1.650	1.656	(?)	3_9(?)	14_5	(?)	−58° 10′	2° 43′				(253)
Mg	K	1.497_0	1.499_1	1.513_8	−1	29	68	6	39 42^b	− 0 17		−3+		(207)
	Rb	1.501_1	1.503_1	1.513_5	−1	29	67	5	47 24	− 1 1_8^b		−3		(207)
	Cs	1.5178	1.517_9	1.5236	+2	30	70	3	20 34^b	−10 4^b		−3		(207)
	NH_4	1.507_0	1.509_8	1.516_9	0	31	72	4	54 54^b	− 0 51	−1+¶	−3¶	−3¶	(133, 209)
	Tl**	1.625	1.633+	1.640+	(?)	4_0(?)	11_5(?)	(?)	−77 20	0 50				(253)
							$R'' R_2(CrO_4)_2.6H_2O$							
Mg	Rb	1.621_5	1.633_0	1.643_5	-4_2	10_0	35_6	1_8	−88 4^b	+ 6 4^b	−3	−4	−4	(220)
	Cs	1.636_9	1.642_4	1.654_6	-1_2	9_4	33_2	31	+67 7^b	− 2 20^c		−4+		(220)
	NH_4	1.636_1	1.637_2	1.653_0	-8_8	10_0	35_6	7_8	8 54^a	+41 0^d		−4		(133, 220)

$R''R_2(SO_4)_2.6H_2O$ (133)

$R'' = Zn$, $R = Tl$

λ	δ_{β_D}
434*G′*	202
436Hg	198+
486*F*	111
502He	88+
535Tl	49+
546Hg	37+
578Hg	8+
656*C*	− 47
668He	− 53+
671Li	− 55

$\delta\alpha_D = 0.94\delta\beta_D$

$\delta\gamma_D = 1.075\delta\beta_D$

$R'' = Co$, $R = K$

λ	δ_{β_D}
405Hg	126
434*G′*	95
486*F*	54
535Tl	25
656*C*	− 24
706He	− 38+

$\delta\alpha_D = 0.96\delta\beta_D$

$\delta\gamma_D = 1.06\delta\beta_D$

$R'' = Ni$, $R = Rb$

λ	δ_{β_D}
434*G′*	97
486*F*	55
656*C*	− 24
687*B*	− 33

$\delta\alpha_D = 0.97\delta\beta_D$ *ca.*

$\delta\gamma_D = 1.04\delta\beta_D$ *ca.*

$R'' = Ni$, $R = Tl$

λ	δ_{β_D}
436Hg	207
486*F*	116
535Tl	52
656*C*	− 49
668He	− 58

$\delta\alpha_D = 0.975\delta\beta_D$

$\delta\gamma_D = 1.05\delta\beta_D$

$R'' = Cu$, $R = K$

λ	δ_{β_D}
434*G′*	107
486*F*	60+
656*C*	− 26

$\delta\alpha_D = 0.95\delta\beta_D$

$R'' = Co$, $R = NH_4$

λ	δ_{β_D}
434*G′*	112+
486*F*	63+
656*C*	− 28+

$\delta\alpha_D = 0.94\delta\beta_D$

$R'' = Co$, $R = Rb$

λ	δ_{β_D}
434*G′*	95
486*F*	53
656*C*	− 24
687*B*	− 34
716*a*	− 42

$\delta\alpha_D = 0.97\delta\beta_D$

$\delta\gamma_D = 1.06\delta\beta_D$

$R'' = Co$, $R = NH_4$

λ	δ_{β_D}
405Hg	138+
434*G′*	104+
486*F*	59+
535Tl	27+
656*C*	− 26
706He	− 42

$\delta\alpha_D = 0.97\delta\beta_D$

$\delta\gamma_D = 1.04\delta\beta_D$

$R'' = Ni$, $R = NH_4$

λ	δ_{β_D}
405Hg	140+
434*G′*	105+
486*F*	59+
656*C*	− 25+
706He	− 42

$\delta\alpha_D = 0.96\delta\beta_D$

$\delta\gamma_D = 1.04\delta\beta_D$‡

$Mg(NH_4)_2(SeO_4)_2.6H_2O$ (133)

λ	δ_{β_D}	λ	δ_{β_D}
405Hg	171	434*G′*	129
486*F*	71+	535Tl	32+
656*C*	− 30+	706He	− 49+

$\delta\alpha_D = \delta\beta_D$, $\delta\gamma_D = 1.05\delta\beta_D$

$Mg(NH_4)_2(CrO_4)_2.6H_2O$ (133)

λ	δ_{α_D}	δ_{β_D}	δ_{γ_D}
486*F*	32_6	356	414
492He		319	
502He		271	315
509Cd	219	239	277
535Tl	126	138	159
546Hg		104	
578Hg		24	
588He		3	3
656*C*	− 92	−100	−115
668He		−122	−140
671Li	−114	−124	−142

* For $Fe(NH_4)_2(SO_4)_2.6H_2O$, $\tau\alpha_F = -2.2$, $\tau\beta_F = -2.8$, $\tau\gamma_F = -3.2$; and for red, $\tau\alpha = -2.8$, $\tau\beta = -4.0$, $\tau\gamma = -3.6$.

† For $Mg(NH_4)_2(SO_4)_2.6H_2O$, values of τ apply to all colors.

‡ For Ni $(NH_4)_2(SO_4)_2.6H_2O$, strong absorption of γ at $\lambda = 405$ and 706.

§ For $Zn(NH_4)_2(SeO_4)_2.6H_2O$, $\tau\alpha_F = -1+$, $\tau\alpha_{Li} = -2+$.

‖ Recalculated.

¶ For $Mg(NH_4)_2(SeO_4)_2.6H_2O$, values of τ apply if $486F < \lambda < 671Li$.

** Accuracy of $2V$, and $2(V_F - V_C)$ not estimated.

TABLE 4.—CONVERSION OF TEMPERATURE COEFFICIENTS OF REFRACTION FROM VACUUM TO AIR

Assuming that the air and crystal are at the same temperature, and writing $10^{-5}\tau = d(index)/dt$, and $\Delta = \tau_{air} - \tau_{vac}$, Δ is directly proportional to the pressure of the air, and increases by 2% in going from the red ($\lambda = 650m\mu$) to the violet ($\lambda = 400m\mu$). The tabulated values refer to $\lambda = 650m\mu$ and air at a pressure of 760 mm of Hg.

Index	1.3	1.7	2.2	3.0
Range, °C	Δ			
−100 to −50	0.25	0.32	0.42	0.58
− 50 to 0	0.17	0.22	0.29	0.39
0 to 50	0.12	0.15	0.20	0.27
50 to 150	0.08	0.10	0.13	0.17+
150 to 300	0.04	0.06	0.07	0.10
0 to 150	0.09	0.12	0.15	0.21

LITERATURE

(For a key to the periodicals, see end of volume)

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REFRACTIVITY OF PURE ORGANIC LIQUIDS

ALFRED L. DIXON AND CLARENCE J. WEST

(The numerical data for the following compounds, which were selected from the literature by Alfred L. Dixon and Dr. Roger Adams, were compiled by Clarence J. West.)

The following table gives values for the density and the refractive indices for the $H_\alpha(\alpha)$, D(He values are *), $H_\beta(\beta)$ and $H_\gamma(\gamma)$ lines for the more important carbon compounds. In the literature column, the citation from which the values were selected is followed by a †. Values of wave-lengths represented by symbols are: H_α (α), 656.3mμ; H_β (β), 486.15mμ; H_γ (γ), 434.06mμ; D(Na), 589.3mμ; He, 587.6mμ.

ℭ-Table; The ℭ-Arrangement (*v.* Vol. III. p. viii) (Metallo-organic compounds at end of table)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
CCl_3NO_2	Trichloronitromethane	22.8	1.6511	1.45793	1.46075	1.46785	1.47377	(106)
CCl_4	Carbon tetrachloride	12.3	1.6095	1.4599	1.4656	1.4726	1.4835	(132)
CN_4O_8	Tetranitromethane	16.9	1.6425	1.43628	1.43976*	1.44835	1.45593	(74)
CS_2	Carbon disulfide	18	1.2661	1.62011	1.62950	1.65439	1.67665	(111,† 112, 132, 133, 134, 149, 153, 154)
$CHBr_3$	Bromoform	19.0	2.891	1.5875	1.5980	1.6107	1.6334	(132,† 134)
$CHCl_3$	Chloroform	18	1.4844	1.44389	1.44643	1.45271	1.45779	(111,† 112, 124, 132, 134, 149)
CH_2I_2	Methylene iodide	10.5	3.344	1.7275	1.7559	1.7750	1.8229(?)	(132)
CH_2O_2	Formic acid	20	1.2188	1.36927	1.37137	1.37643	1.38041	(147)
CH_3I	Methyl iodide	21.0	2.274	1.5185	1.5293	1.5423	1.5652	(132,† 134)
CH_3NO	Formamide	22.7	1.1313	1.44292	1.44530	1.45426	1.46085	(106)
CH_3NO_2	Nitromethane	21.6	1.1354	1.37884	1.38133	1.38771	1.39305	(106)
$CH_4N_2O_2$	Methylnitroamine	48.6	1.2433	1.45722	1.46162	1.47211	1.48176	(109)
CH_4O	Methanol	14.50	0.7980	1.32948	1.33118	1.33490	1.33801	(122, 124, 148)
CH_5NO	β-Methylhydroxylamine	20.0	1.0003	1.41415	1.41638	1.42196	1.42639	(103,† 106)
$C_2Br_4N_2$	Isocyanotetrabromide	55.0	2.6796	1.63917	1.64650		1.68421	(109)
$C_2Cl_2O_2$	Oxalyl chloride	12.9	1.4888	1.43111	1.43395	1.44121	1.44743	(80)
C_2Cl_4	Perchloroethylene	20	1.6226	1.50153	1.50547	1.51522	1.52368	(92)
C_2HBr_3	Tribromoethylene	20	2.6876	1.59431	1.59919	1.61358	1.62548	(164)
C_2HCl_3O	Chloral	20	1.5121	1.45298	1.45572	1.46235	1.46786	(93)
C_2HCl_5	Pentachloroethane	24.0	1.6697	1.49946	1.50250	1.50984	1.51576	(141)
$C_2H_2Br_2$	Acetylene dibromide	20	2.2289	1.53898	1.54367	1.55548	1.56555	(164)
$C_2H_2Br_4$	1, 1, 1, 2-Tetrabromoethane	20	2.8748	1.62244	1.62772	1.64130	1.65290	(164)
$C_2H_2Br_4$	1, 1, 2, 2-Tetrabromoethane	20	2.9673	1.63263	1.63795	1.65114	1.66249	(164)
$C_2H_2Cl_4$	1, 1, 1, 2-Tetrachloroethane	23.2	1.5466	1.47880	1.48162	1.48847	1.49405	(141)
$C_2H_3Br_3$	1, 1, 2-Tribromoethane	20	2.5790	1.58444	1.58902	1.60064	1.61050	(164)
C_2H_3ClO	Acetyl chloride	20	1.1051	1.38736	1.38976	1.39543	1.40002	(80, 93†)
$C_2H_3Cl_3$	1, 1, 1-Trichloroethane	21.0	1.3345	1.43287	1.43765	1.44176	1.44961	(91)
$C_2H_3Cl_3$	1, 2, 2-Trichloroethane	22	1.4458	1.46927	1.47192	1.47862	1.48402	(141)
C_2H_3N	Acetonitrile	16.5	0.7863	1.34427	1.34596	1.35004	1.35333	(106)
C_2H_3NS	Methyl thiocyanate	23.8	1.0694	1.46509	1.46801	1.47624	1.48285	(158, 159)
$C_2H_3N_3$	1, 2, 5-Triazole	25.3	1.1861	1.48189	1.48544	1.49432	1.50168	(106)
$C_2H_4Br_2$	1, 1-Dibromoethane	20	2.0555	1.50900	1.51277	1.52215	1.53004	(164)
$C_2H_4Br_2$	1, 2-Dibromoethane	20	2.1768	1.53396	1.53789	1.54793	1.55624	(140, 164†)
$C_2H_4Cl_2$	1, 1-Dichloroethane	20	1.1743	1.41423	1.41655	1.42226	1.42671	(93, 164†)
$C_2H_4Cl_2$	1, 2-Dichloroethane	20	1.2521	1.44189	1.44432	1.45024	1.45528	(93, 140, 141, 164†)
C_2H_4O	Ethylene oxide	8.4	0.8896	1.35819	1.35988	1.36411	1.36759	(16)
$C_2H_4O_2$	Acetic acid	22.9	1.0446	1.36944	1.37152	1.37610	1.38003	(125,† 147)
C_2H_5Br	Ethyl bromide	20	1.4555	1.42113	1.42386	1.43046	1.43595	(164)
C_2H_5I	Ethyl iodide	7.0	1.9671	1.5124	1.5222	1.5343	1.5551	(132,† 134, 149)
C_2H_5NO	Acetaldoxime	20.4	0.9656	1.42290	1.42567	1.43270	1.43834	(106)
$C_2H_5NO_2$	Nitroethane	24.3	1.0472	1.38768	1.39007		1.40102	(106)
$C_2H_5NO_3$	Ethyl nitrate	21.5	1.1050	1.38254	1.38484		1.39511	(106)
$C_2H_6N_2O$	Nitrosodimethylamine	18.4	1.0049	1.43368	1.43743		1.45506	(106)
$C_2H_6N_2O_2$	Dimethylnitroamine	72.3	1.1090	1.44246	1.44622		1.46519	(109)
C_2H_6O	Ethyl alcohol	18.35	0.7917	1.36062	1.36242	1.36662	1.37011	(122,† 133, 148, 149)
C_2H_6S	Ethylmercaptan	20	0.83907	1.42769	1.43055	1.43788	1.4445	(153,† 154)
C_2H_7NO	β-Ethylhydroxylamine	63.9	0.9079	1.41381	1.41519		1.42463	(103, 106†)
$C_2H_8N_2$	*asym.*-Dimethylhydrazine	22.3	0.7914	1.40503	1.40753	1.41429	1.41990	(108, 109†)
$C_2H_8N_2$	Ethylenediamine	26.1	0.8919	1.45113	1.45400	1.46065	1.46624	(106)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_2H_{10}N_2O$	Ethylenediamine hydrate	20.5	0.9634	1.44732	1.44997	1.45630	1.46148	(106)
$C_3H_2Cl_2O_2$	Malonyl chloride	22.1	1.4488	1.45866	1.46172	1.46904		(80)
$C_3H_2N_2$	Malononitrile	34.2	1.0488	1.41259	1.41463		1.42371	(106)
C_3H_3NO	Isoxazole	16.6	1.0805	1.42685	1.42981*	1.43701	1.44321	(31)
$C_3H_4N_2$	Pyrazole	99.8	1.0012	1.46633	1.47027*	1.47946	1.48666	(60)
C_3H_4O	Propargyl alcohol	20	0.9715	1.42796	1.43064	1.43734	1.44277	(92)
C_3H_4O	Acrolein	20	0.8410	1.39620	1.39975	1.40890	1.41691	(43,† 92)
$C_3H_4O_3$	Pyrotartaric acid	15.3	1.2668	1.42768	1.43025		1.44110	(105)
C_3H_5Br	Allyl bromide	20	1.3980	1.46166	1.46545	1.47486	1.48297	(92)
C_3H_5Cl	Allyl chloride	20	0.9379	1.41245	1.41538	1.42248	1.42837	(95)
C_3H_5ClO	Epichlorohydrin	11.55	1.1927	1.43990	1.44195	1.44784	1.45264	(16,† 96)
C_3H_5ClO	Propionyl chloride	20	1.0646	1.40264	1.40507	1.41066	1.41541	(93)
C_3H_5N	Propionitrile	14.6	0.7872	1.36711	1.36888		1.37679	(106,† 132)
C_3H_5NO	Lactonitrile	18.4	0.9919	1.40374	1.40582		1.41454	(106)
C_3H_6	Trimethylene	17.7	1.2105	1.43751	1.44021	1.44632	1.45131	(100)
C_3H_6ClNO	Dimethylchloroformamide	22.1	1.1657	1.44904	1.45196	1.45924	1.46538	(109)
$C_3H_6I_2$	Trimethylene iodide	7.5	2.589	1.6347	1.6479	1.6643	1.6940	(132)
C_3H_6O	Allyl alcohol	20	0.8540	1.41051	1.41345	1.42004	1.42556	(92)
C_3H_6O	Propionaldehyde	20	0.8066	1.36157	1.36356	1.36825	1.37203	(92)
C_3H_6O	Acetone	19.4	0.79115	1.35672	1.35886	1.36366	1.36750	(125,† 134)
$C_3H_6O_2$	Propionic acid	19.9	0.98706	1.38535	1.38736	1.39220	1.39596	(125,† 147)
$C_3H_6O_2$	Ethyl formate	20	0.91678	1.35789	1.35975	1.36416	1.36762	(125,† 134)
$C_3H_6O_2$	Methyl acetate	20	0.92438	1.35745	1.35935	1.36357	1.36707	(125)
C_3H_7Br	Isopropyl bromide	20	1.3097	1.42230	1.42508	1.43165	1.43709	(93)
C_3H_7Br	*n*-Propyl bromide	20	1.3529	1.43142	1.43414	1.44064	1.44625	(93)
C_3H_7Cl	*n*-Propyl chloride	20	0.8898	1.38659	1.38856	1.39344	1.39747	(92)
$C_3H_7Cl_2N$	Propyldichloroamine	23	1.1454	1.44940	1.45248		1.46595	(106)
C_3H_7I	Isopropyl iodide	20	1.7033	1.49519	1.49969	1.51080	1.52026	(93)
C_3H_7I	*n*-Propyl iodide	20	1.7427	1.50082	1.50508	1.51566	1.52467	(93)
C_3H_7N	Allylamine	21.8	0.7613	1.41645	1.41943	1.42686	1.43307	(106)
C_3H_7NO	Dimethylformamide	22.4	0.9484	1.42649	1.42938	1.43651	1.44254	(109)
$C_3H_7NO_2$	Nitropropane	24.3	1.0081	1.39787	1.40027		1.41104	(106)
$C_3H_8N_2O_2$	Ethylmethylnitroamine	19.2	1.0972	1.45326	1.45711	1.46668	1.47536	(109)
C_3H_8O	Isopropyl alcohol	20	0.7887	1.37569	1.37757	1.38210	1.38572	(93)
C_3H_8O	*n*-Propyl alcohol	20	0.8044	1.38345	1.38543	1.39008	1.39378	(92,† 148)
$C_3H_8O_2$	Methylal	20	0.8604	1.35183	1.35344	1.35763	1.36085	(28, 93,† 108, 112)
C_3H_9N	*n*-Propylamine	16.6	0.7209	1.38793	1.39006	1.39532	1.39956	(106,† 132)
C_3H_9N	Isopropylamine	15.4	0.6935	1.37488	1.37698		1.38620	(106)
C_4N_2	Acetylene dicyanide	25	0.9703	1.46021	1.46471	1.47610	1.48593	(151)
$C_4HCl_3O_2$	*asym.*-Chloromaleyl chloride	18.1	1.6049	1.50948	1.51362	1.52356	1.53229	(80)
$C_4HCl_3O_2$	Chlorofumaryl chloride	17.6	1.5662	1.51663	1.52172	1.53447	1.54625	(80)
$C_4H_2Br_2S$	α, α′-Dibromothiophene	13.8	2.1531	1.62643	1.63315*	1.64989	1.66504	(59)
$C_4H_2Cl_2O_2$	Fumaryl chloride	18.1	1.4103	1.49592	1.50038	1.51274	1.52360	(80)
$C_4H_2Cl_3N$	γ, γ, γ-Trichlorocrotononitrile	11.2	1.4319	1.50837	1.51225	1.52242	1.53138	(86)
$C_4H_2Cl_4O$	Trichlorocrotonyl chloride	18.8	1.5292	1.51414	1.51812	1.52890	1.53823	(86)
C_4H_3BrS	α-Bromothiophene	15.8	1.6900	1.58350	1.58927*	1.60365	1.61644	(59)
C_4H_3ClS	α-Chlorothiophene	14.2	1.2838	1.54556	1.55068*	1.56333	1.57458	(59)
$C_4H_3Cl_2N$	γ, γ-Dichlorocrotononitrile	20	1.3049	1.49369	1.49735	1.50714	1.51500	(86)
$C_4H_3Cl_3O$	γ, γ-Dichlorocrotonyl chloride	19.6	1.4429	1.49547	1.49928	1.50818	1.51674	(86)
$C_4H_4Cl_2O_2$	Succinyl chloride	15.2	1.3948	1.47042	1.47348	1.48076	1.48702	(80)
$C_4H_4Cl_2O_2$	γ, γ-Dichlorocrotonic acid	99.4	1.3327	1.45680	1.45966	1.46777	1.47565	(86)
$C_4H_4N_2$	Ethylene dicyanide	63.1	0.9848	1.41432	1.41645		1.42543	(106)
$C_4H_4N_2$	Pyrazine	60.9	1.0311	1.49037	1.49526		1.52040	(109)
$C_4H_4N_2$	Pyridazine	23.5	1.1035	1.51842	1.52311	1.53541	1.54641	(109)
C_4H_4O	Furfurane	20	0.9366	1.41837	1.42157	1.42967	1.43668	(41)
$C_4H_4O_3$	γ-Hydroxy-Δ′-crotonolactone	99.3	1.2621	1.45349	1.45632	1.46464		(86)
C_4H_4S	α-Thiophene	16.8	1.0674	1.52570	1.53072*	1.54309	1.55392	(59,† 109, 144, 157, 158, 159)
$C_4H_5BrN_2$	3-Methyl-4-bromopyrazole	99.6	1.5638	1.51402	1.51823*	1.52820	1.53677	(60)
C_4H_5BrO	α-Bromocrotonaldehyde	13.3	1.5797	1.51682	1.52142	1.53460	1.54578	(53)
C_4H_5ClO	Crotonyl chloride	17.9	1.0818	1.45594	1.46001	1.47060	1.47993	(80)
$C_4H_5Cl_3O$	γ, γ, γ-Trichlorobutyraldehyde	20	1.3956	1.47259	1.47554	1.48198	1.48736	(93)
$C_4H_5Cl_3O$	Ethyl trichloroacetate	20	1.3826	1.44802	1.45068	1.45673	1.46176	(93)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
C_4H_5N	Crotononitrile	18.9	0.8225	1.41310	1.41607	1.42405	1.43080	(58)
C_4H_5N	Pyrrole	13.9	0.9613	1.50399	1.50851*	1.51955	1.52908	(60,† 106)
C_4H_5NO	α-Methylisoxazole	16.7	1.0259	1.43775	1.44087*	1.44826	1.45484	(31)
C_4H_5NO	γ-Methylisoxazole	18.15	1.0238	1.43296	1.43590*	1.44279	1.44882	(31)
$C_4H_6Br_2$	Dimethylacetylene dibromide	25.45	1.3180	1.45280	1.45616	1.46430	1.47115	(107)
$C_4H_6Cl_2O$	β-Chlorobutyryl chloride	20.05	1.2165	1.44833	1.45085	1.45774	1.46341	(66)
$C_4H_6Cl_2O_2$	Ethyl dichloroacetate	20	1.2821	1.43615	1.43860	1.44435	1.44894	(93)
$C_4H_6N_2$	3-Methylpyrazole	16.3	1.0203	1.49330	1.49717*	1.50656	1.51465	(60)
$C_4H_6N_2$	*C*-Methylpyrazole	13.7	1.0227	1.49042	1.49412	1.50362	1.51157	(157)
$C_4H_6N_2O$	Dimethylfurazane	18.9	1.0495	1.42477	1.42713	1.43316	1.43816	(109)
$C_4H_6N_2O_2$	Ethyl diazoacetate	17.6	1.0852	1.45447	1.45876	1.47017	1.47994	(106)
C_4H_6O	Crotonaldehyde	17.3	0.8557	1.43415	1.43838	1.44908	1.45852	(43,† 44)
$C_4H_6O_2$	Trimethylenecarboxylic acid	17.1	1.0907	1.43488	1.43754	1.44363	1.44856	(110)
$C_4H_6O_2$	Methylacrylic acid	20	1.0153	1.42815	1.43143	1.43959	1.44635	(92, 94)
$C_4H_6O_2$	Isocrotonic acid	19.6	1.0261	1.44203	1.44579*	1.45495	1.46276	(69)
$C_4H_6O_2$	Diacetyl	18.5	0.9808	1.39105	1.39331	1.39897	1.40317	(18, 105†)
C_4H_7Br	2-Bromo-2-butene	25.35	1.3216	1.45490	1.45828	1.46637	1.47337	(107)
C_4H_7ClO	Butyryl chloride	20	1.0277	1.40971	1.41209	1.41781	1.42249	(93)
$C_4H_7ClO_2$	β-Chlorobutyric acid	19.85	1.1865	1.43992	1.44213	1.44828	1.45327	(66)
$C_4H_7ClO_2$	Ethyl chloroacetate	20	1.1585	1.42056	1.42274	1.42812	1.43228	(93)
$C_4H_8N_2O_3$	Nitrosomethylurethane	19.0	1.1402	1.43566	1.43905	1.44807		(118)
$C_4H_8N_2O_4$	Ethyl methylnitrocarbamate	23.0	1.2288	1.44507	1.44826	1.45628	1.46330	(109)
C_4H_8O	*n*-Butyraldehyde	20	0.8170	1.38222	1.38433	1.38932	1.39321	(93)
C_4H_8O	Isobutyraldehyde	20	0.7938	1.37094	1.37302	1.37769	1.38170	(93)
C_4H_8O	Methyl ethyl ketone	15.9	0.8087	1.37844	1.38071	1.38554	1.38938	(125)
$C_4H_8O_2$	*n*-Butyric acid	20.3		1.39582	1.39777	1.40271	1.40685	(131,† 147)
$C_4H_8O_2$	Isobutyric acid	20	0.9490	1.39093	1.39300	1.39722	1.40166	(92, 94)
$C_4H_8O_2$	Ethyl acetate	18.9	0.89464	1.37023	1.37216	1.37662	1.38022	(125,† 134, 149)
$C_4H_8O_2$	Methyl propionate	18.5	0.91662	1.37570	1.37767	1.38218	1.38596	(125)
$C_4H_8O_2$	Diethylene dioxide	16.8	1.0366	1.42003	1.42218*	1.42720	1.43146	(1)
$C_4H_9Cl_2N$	Isobutyldichloroamine	24.0	1.0895	1.44544	1.44843	1.45577	1.46150	(106)
C_4H_9I	*n*-Butyl iodide	20	1.6166	1.49601	1.50006	1.51005	1.51844	(93)
C_4H_9I	Isobutyl iodide	20	1.6056	1.49192	1.49597	1.50566	1.51398	(93,† 132
C_4H_9NO	Acetimidoethyl ether	18.8	0.8729	1.40122	1.40348	1.40887	1.41326	(109)
C_4H_9NO	Dimethylacetamide	22.5	0.9409	1.43436	1.43708	1.44398	1.44976	(109)
C_4H_9NO	Isobutyraldoxime	20.5	0.9015	1.42752	1.43022		1.44243	(106)
$C_4H_9NO_2$	Isobutyl nitrite	22.1	0.8699	1.36932	1.37151	1.37708	1.38196	(106)
$C_4H_9NO_3$	Isobutyl nitrate	23.3	1.0112	1.39904	1.40130	1.40699	1.41171	(106)
$C_4H_{10}N_2O$	Nitrosodiethylamine	19.9	0.9431	1.43535	1.43864		1.45422	(106)
$C_4H_{10}N_2O_2$	*n*-Butylnitroamine	23.0	1.0579	1.45680	1.46039	1.46906	1.47665	(109)
$C_4H_{10}N_2O_2$	*sec.*-Butylnitroamine	21.9	1.0566	1.45457	1.45810	1.46648	1.47395	(109)
$C_4H_{10}O$	*n*-Butyl alcohol	20	0.8099	1.39712	1.39909	1.40395	1.40773	(93)
$C_4H_{10}O$	Isobutyl alcohol	17.5	0.8046	1.3948	1.3968	1.4016	1.4055	(148)
$C_4H_{10}O$	Trimethyl carbinol	20	0.7864	1.38572	1.38779	1.39243	1.39618	(93)
$C_4H_{10}O$	Ethyl ether	17.1	0.7183	1.35246	1.35424	1.35854	1.36189	(108,† 133, 134, 149)
$C_4H_{10}O_3S$	Ethyl ethylsulfonate	22	1.1452	1.41733	1.41959	1.42420	1.42864	(153, 154)
$C_4H_{10}S$	Ethyl sulfide	20.5	0.8362	1.43970	1.44253	1.44960	1.45543	(109,† 153, 154)
$C_4H_{10}S$	Isobutylmercaptan	20	0.8357	1.43575	1.43859	1.44547	1.4511	(153, 154)
$C_4H_{10}S_2$	Ethyl disulfide	20	0.99267	1.50306	1.50633	1.51604	1.52407	(153, 154)
$C_4H_{11}N$	Diethylamine	17.6	0.7108	1.38510	1.38730	1.39264	1.39703	(106)
$C_4H_{11}N$	*sec.*-Butylamine	16.7	0.7271	1.39280	1.39501		1.40453	(106)
$C_4H_{11}N$	Isobutylamine	17.0	0.7359	1.39664	1.39878		1.40829	(106)
$C_4H_{11}N$	*tert.*-Butylamine	18.0	0.6978	1.37740	1.37940	1.38440	1.38868	(109)
$C_4H_{11}O_3P$	Diethylphosphorous acid	10	1.0757	1.40624	1.40823	1.41300	1.41699	(2)
$C_5H_4O_2$	Coumalin	19.45	1.1984	1.52377	1.53005	1.54859	1.56674	(23)
$C_5H_4O_2$	Furfural	20	1.1594	1.51862	1.52608	1.54566	1.56484	(95)
$C_5H_4O_3$	Citraconic anhydride	20	1.2542	1.46774	1.47166	1.48154	1.49026	(45†, 144)
$C_5H_5Cl_3O_2$	Methyl γ, γ, γ-trichlorocrotonate	21.2	1.3970	1.48621	1.48975	1.49883	1.50635	(81)
C_5H_5N	Pyridine	21	0.9808	1.50456	1.50919	1.52118	1.53153	(106,† 134, 145, 157)
$C_5H_6Cl_2O_2$	3, 3, Dichloroacetylacetone	16.75	1.3067	1.45648	1.45885	1.46547	1.47109	(34)
$C_5H_6Cl_2O_2$	α, δ-Dichloro-γ-valerolactone	24.6	1.4363	1.49367	1.49624	1.50286	1.50838	(80)
$C_5H_6Cl_2O_2$	Methyl γ, γ-dichlorocrotonate	17.7	1.3050	1.46744	1.47040	1.47811	1.48442	(86)
$C_5H_6Cl_2O_2$	Glutaryl chloride	20.2	1.3239	1.47004	1.47281	1.47989	1.48576	(80)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_5H_6N_2$	Methylpyrazine	18.7	1.0302	1.50170	1.50666		1.53164	(109)
$C_5H_6N_2$	Trimethylene dicyanide	23.2	0.9888	1.4318	1.4365	1.4420	1.4514	(132)
$C_5H_6N_2O_3$	Methyl methyloximinocyanoacetate	20	1.1768	1.4551	1.4591	1.4693	1.4788	(152)
$C_5H_6O_2$	α-Angelolactone	13.2	1.0904	1.44776	1.45064*	1.45771	1.46381	(28)
$C_5H_6O_2$	β-Angelolactone	15.2	1.0783	1.45936	1.46268*	1.47092	1.47813	(28)
$C_5H_6O_2$	Propargyl acetate	20	1.0052	1.41796	1.42047	1.42659	1.43163	(92)
C_5H_6S	α-Thiotolene	15.3	1.0231	1.51919	1.52388*	1.53555	1.54586	(59)
C_5H_6S	β-Thiotolene	14.8	1.0268	1.51910	1.52380*	1.53538	1.54564	(59)
$C_5H_7BrN_2$	1, 3-Dimethyl-4-bromopyrazole	14.7	1.4976	1.51652	1.52137*	1.53078	1.54056	(38)
$C_5H_7Br_2N$	α, β-Dibromovaleronitrile	17.6	1.7598	1.51766	1.52133*	1.53019	1.53881	(69)
$C_5H_7ClN_2$	1, 3-Dimethyl-4-chloropyrazole	17.1	1.1604	1.49102	1.49462*	1.50327	1.51115	(38)
$C_5H_7ClN_2$	1, 5-Dimethyl-4-chloropyrazole	17.7	1.1686	1.49349	1.49725*	1.50592	1.51335	(38)
C_5H_7ClO	β, β-Dimethylacryl chloride	12.35	1.0652	1.47479	1.47980*	1.49137	1.50231	(69)
C_5H_7ClO	α, β-Pentenyl chloride	18.0	1.0653	1.46225	1.46616*	1.47597	1.48481	(69)
C_5H_7ClO	β, γ-Pentenyl chloride	16.9	1.0666	1.44716	1.44990*	1.45733	1.46383	(69)
$C_5H_7ClO_2$	3-Chloroacetylacetone	16.7	1.1686	1.47485	1.47976	1.49389		(34)
$C_5H_7ClO_2$	Methyl α-chlorocrotonate	22.6	1.1587	1.45302	1.45634	1.46477	1.47187	(126)
C_5H_7N	*N*-Methylpyrrole	16.0	0.9106	1.48454	1.48890*	1.49945	1.50859	(60)
C_5H_7N	α, β-Pentenonitrile	15.5	0.8311	1.43134	1.43472*	1.44308	1.44988	(69)
C_5H_7N	β, γ-Pentenonitrile	18.8	0.8423	1.42084	1.42358*	1.42998	1.43547	(58, 69†)
C_5H_7NO	α, γ-Dimethylisoxazole	16.7	0.9864	1.44102	1.44393*	1.45115	1.45736	(31)
$C_5H_7NO_2$	Ethyl cyanoacetate	20.5	1.0629	1.41584	1.41793	1.42312	1.42730	(106)
C_5H_8	Cyclopentene	7.1	0.7861	1.42818	1.43052	1.43746	1.44306	(16)
C_5H_8	1, 1-Dimethylallene	3.3	0.6915	1.41396	1.41722	1.42664	1.43450	(18)
C_5H_8	Valerylene	20	0.6786	1.39763	1.40044	1.40726	1.41304	(92)
$C_5H_8Cl_2O_2$	Ethyl dichloropropionate	20	1.2461	1.44553	1.44815	1.45379	1.45854	(93)
$C_5H_8N_2$	1, 3-Dimethylpyrazole	15.2	0.9628	1.46769	1.47118*	1.47959	1.48686	(60)
$C_5H_8N_2O$	Ethylmethylfurazan	18.8	1.0180	1.43022	1.43257	1.43861	1.44356	(109)
C_5H_8O	Cyclopentanone	17.3	0.9513	1.43587	1.43817	1.44390	1.44867	(55)
C_5H_8O	Ethylideneacetone	19.6	0.8577	1.43536	1.43903	1.44846	1.45680	(43)
C_5H_8O	Propargyl ethyl ether	20	0.8326	1.40152	1.40390	1.40964	1.41439	(92)
$C_5H_8O_2$	Acetylacetone	18.5	0.9771	1.44696	1.45178	1.46450	1.47758	(17,† 56, 105, 131)
$C_5H_8O_2$	Acetylpropionyl	19.0	0.9565	1.39918	1.40135		1.41134	(105)
$C_5H_8O_2$	Angelic acid	100	0.9295	1.41674	1.41998*	1.42846	1.43593	(69)
$C_5H_8O_2$	Cyclobutanecarboxylic acid	16.6	1.0570	1.44151	1.44393	1.44976	1.45453	(110,† 130)
$C_5H_8O_2$	α, β-Pentenic acid	14.7	0.9947	1.44977	1.45370*	1.46269	1.47068	(69)
$C_5H_8O_2$	β, γ-Pentenic acid	18.8	0.9885	1.43285	1.43569*	1.44248	1.44821	(69)
$C_5H_8O_2$	Tiglic acid	99.7	0.9425	1.42435	1.42746*	1.43629	1.44407	(69)
$C_5H_8O_2$	Allyl acetate	20	0.9276	1.40205	1.40448	1.41059	1.41561	(92)
$C_5H_8O_3$	Levulinic acid	15.8	1.1449	1.43941	1.44217	1.44765	1.45267	(49,† 105)
$C_5H_8O_3$	Ethyl pyruvate	15.6	1.0596	1.40606	1.40830	1.41361	1.41825	(6)
$C_5H_8O_3$	Methyl acetoacetate	20.5	1.0756	1.41616	1.41837	1.42418	1.42906	(9,† 105)
$C_5H_8O_3$	Methyl α-methoxyacrylate	18.95	1.0702	1.42911	1.43207	1.43960	1.44614	(5)
$C_5H_8O_4$	Dimethyl malonate	17.3	1.1571	1.41284	1.41490	1.41791	1.42420	(105)
C_5H_9ClO	Isovaleryl chloride	24.3	0.9854	1.41116	1.41361	1.41933	1.42391	(80)
C_5H_9ClO	Valeryl chloride	20	0.9887	1.41318	1.41555	1.42131	1.42599	(93)
$C_5H_9ClO_2$	Ethyl α-chloropropionate	20	1.0869	1.41623	1.41850	1.42370	1.42805	(93)
C_5H_{10}	Amylene	20	0.6476	1.37330	1.37576	1.38127	1.38588	(92,† 134, 148)
C_5H_{10}	2-Pentene	14.7	0.6574	1.38141	1.38354	1.38998	1.39530	(16)
$C_5H_{10}Br_2$	Amylene bromide	15	1.6700	1.5060	1.5094	1.5178	1.5240	(140)
$C_5H_{10}N_2O$	Nitrosopiperidine	18.5	1.0631	1.48940	1.49328		1.51197	(106)
$C_5H_{10}N_2O_2$	Nitropiperidine	26.4	1.1519	1.49152	1.49540	1.50526	1.51392	(109)
$C_5H_{10}N_2O_3$	Nitrosoethylurethane	16.9	1.0885	1.43354	1.43676	1.44530		(118, 119)
$C_5H_{10}O$	Cyclopentanol	13.5	0.9533	1.45387	1.45600	1.46169	1.46649	(16)
$C_5H_{10}O$	Allyl ethyl ether	20	0.7651	1.38565	1.38810	1.39387	1.39874	(92)
$C_5H_{10}O$	Diethyl ketone	16.6	0.8175	1.39168	1.39385	1.39877	1.40298	(105, 125†)
$C_5H_{10}O$	Methyl isopropyl ketone	16	0.8046	1.38569	1.38788	1.39268	1.39687	(125)
$C_5H_{10}O$	Methyl propyl ketone	20.2	0.8089	1.38754	1.38946	1.39461	1.39881	(125)
$C_5H_{10}O_2$	Cyclo-γ-hydroxyvaleric aldehyde	17.6	1.0216	1.43365	1.43606*	1.44100	1.44532	(28)
$C_5H_{10}O_2$	Isovaleric acid	22.4	0.95592	1.39964	1.40178	1.40677	1.41107	(125,† 147)
$C_5H_{10}O_2$	Ethyl propionate	20.2	0.88886	1.38193	1.38385	1.38849	1.39225	(125,† 134)
$C_5H_{10}O_2$	Isobutyl formate	19.9	0.88182	1.38386	1.38584	1.39063	1.39469	(125)
$C_5H_{10}O_2$	Propyl acetate	20	0.8865	1.38235	1.38438	1.38903	1.39274	(92)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_5H_{10}O_3$	Diethyl carbonate	20	0.9762	1.38335	1.38523	1.38969	1.39321	(28, 93,† 134)
$C_5H_{11}Br$	Amyl bromide	12.8	1.2214	1.4427	1.4450	1.4517	1.4570	(140)
$C_5H_{11}Cl$	Amyl chloride	18.2	0.8720	1.4076	1.4097	1.4150	1.4192	(140)
$C_5H_{11}Cl$	*tert.*-Amyl chloride	13.5	0.8699	1.4054	1.4082	1.4138	1.4181	(140)
$C_5H_{11}Cl_2N$	Isoamyldichloroamine	25.7	1.0273	1.44110	1.44381		1.45611	(106)
$C_5H_{11}N$	Piperidine	18.7	0.8628	1.45097	1.45350	1.45989	1.46512	(106,† 157)
$C_5H_{11}NO$	Diethyl ketoxime	24.1	0.9083	1.44080	1.44350		1.45550	(106)
$C_5H_{11}NO$	Isovaleraldoxime	22.1	0.8897	1.43382	1.43645		1.44830	(106)
$C_5H_{11}NO$	Propionimido ethyl ether	16.9	0.8707	1.40806	1.41028	1.41571	1.42025	(109)
$C_5H_{11}NO_2$	Diethyl imidocarbonate	18.2	0.9637	1.41472	1.41704	1.42235	1.42674	(109)
$C_5H_{11}NO_2$	Isoamyl nitrite	20.7	0.8717	1.38486	1.38708		1.39761	(106)
$C_5H_{11}NO_2$	Nitroisopentane	20.6	0.9599	1.41570	1.41806		1.42908	(106)
$C_5H_{11}NO_3$	Isoamyl nitrate	21.7	0.9961	1.40987	1.41219		1.42261	(106)
C_5H_{12}	Pentane	15.7	0.6251	1.3581	1.3570	1.3610	1.3645	(148)
$C_5H_{12}N_2O_2$	*n*-Butylmethylnitroamine	23.6	1.0232	1.45282	1.45631	1.46494	1.47250	(109)
$C_5H_{12}N_2O_2$	Isobutylmethylnitroamine	22.5	1.0211	1.45258	1.45607	1.46473	1.47228	(109)
$C_5H_{12}O$	Amyl alcohol	14.60	0.8142	1.40747	1.40963	1.41452	1.41870	(93, 122,† 148)
$C_5H_{12}O$	Isoamyl alcohol	17.8	0.8134	1.4064	1.4084	1.4135	1.4176	(148)
$C_5H_{12}O$	Propyl ethyl ether	20	0.7386	1.36758	1.36948	1.37397	1.37765	(92)
$C_5H_{12}S$	Isoamylmercaptan	20	0.83475	1.43824	1.44118	1.44734	1.45308	(153, 154)
$C_5H_{13}N$	Isoamylamine	17.9	0.7514	1.40739	1.40959		1.41920	(106)
$C_5H_{13}N$	Methyl-*n*-butylamine	18.1	0.7363	1.39950	1.40180	1.40708	1.41145	(108, 109†)
$C_5H_{14}N_2$	*asym.*-Methyl-*n*-butylhydrazine	21.3	0.8040	1.42330	1.42586	1.43196	1.43703	(108, 109†)
$C_6H_3Cl_3$	Trichlorobenzene	20	1.5563	1.5809	1.5671	1.5602	1.5945	(134)
$C_6H_4BrNO_2$	*m*-Bromonitrobenzene	20.1	1.7036	1.59084	1.59791	1.61705	1.63429	(109)
$C_6H_4Br_2$	*m*-Dibromobenzene	18.7	1.9561	1.60303	1.60879	1.62469	1.63829	(47)
$C_6H_4Br_2$	*p*-Dibromobenzene	99.3	1.8201	1.56897	1.57425	1.58939		(47)
$C_6H_4Cl_2$	*o*-Dichlorobenzene	20.4	1.2979	1.54384	1.54848	1.56141	1.57289	(47)
$C_6H_4Cl_2$	*m*-Dichlorobenzene	20.9	1.2879	1.54111	1.54570	1.55887	1.56989	(47)
$C_6H_4Cl_2$	*p*-Dichlorobenzene	80.3	1.2189	1.51673	1.52104	1.53388	1.54455	(47)
C_6H_5Br	Bromobenzene	20	1.4914	1.55439	1.55977	1.57362	1.58557	(47, 92,† 135, 140)
C_6H_5Cl	Chlorobenzene	20	1.1066	1.51986	1.52479	1.53693	1.54750	(47, 92,† 135, 140)
C_6H_5F	Fluorobenzene	22.8	1.0207	1.4563	1.4646	1.4751	1.4849	(135)
C_6H_5I	Iodobenzene	18.5	1.8324	1.61438	1.62145	1.63964	1.65520	(47,† 135)
C_6H_5NO	Pyridine-2-aldehyde	18.5	1.1255	1.53284	1.53886	1.55396	1.56749	(139)
$C_6H_5NO_2$	Nitrobenzene	20	1.2039	1.54593	1.55291	1.57124		(91, 92, 106,† 134)
$C_6H_5N_3$	Diazobenzeneimide	22.5	1.0776	1.55760	1.56421	1.58181	1.59757	(106,† 161)
C_6H_6	Benzene	20	0.8791	1.49663	1.50144	1.51327	1.52361	(20, 92, 132, 134, 144, 148, 162, 164†)
C_6H_6	Dipropargyl	23.8	0.8008	1.43795	1.44132	1.45014	1.45774	(101)
C_6H_6BrN	*m*-Bromoaniline	20.4	1.5793	1.61900	1.62604	1.64550	1.66286	(106)
C_6H_6ClN	*m*-Chloroaniline	20.7	1.2142	1.58753	1.59424		1.62794	(106)
C_6H_6O	Phenol	40.6	1.0596	1.53691	1.54247	1.55581	1.56840	(126,† 133)
C_6H_6OS	α-Acetothienone	21.8	1.1679	1.55940	1.56630*	1.58441	1.60177	(59)
C_6H_6S	Thiophenol	23.2	1.0739	1.57971	1.58613	1.60285	1.61685	(126)
C_6H_7ClO	Sorbyl chloride	18.75	1.0666	1.54707	1.55710*	1.58453		(27)
$C_6H_7Cl_3O_2$	Ethyl γ, γ, γ-trichlorocrotonate	14.2	1.3375	1.48360	1.48693	1.49562	1.50303	(81)
C_6H_7N	Aniline	20	1.0216	1.57948	1.58629	1.60434	1.62074	(92, 106,† 132, 134, 144, 164)
C_6H_7N	α-Methylpyridine	16.7	0.9484	1.49844	1.50293	1.51444	1.52441	(106)
C_6H_7N	β-Methylpyridine	24.0	0.9539	1.49963	1.50432		1.52571	(106)
C_6H_8	Dihydrobenzene	21.2	0.8466	1.46921	1.47296	1.48258	1.49092	(104)
C_6H_8	1, 3, 5-Hexatriene	16.2	0.74067	1.47819		1.50272	1.51958	(45)
$C_6H_8Br_2Cl_2O_2$	Ethyl α, β-dibromo-γ, γ-dichlorobutyrate	22.6	1.8257	1.51936	1.52233	1.53096	1.53787	(86)
$C_6H_8Cl_2O_2$	Ethyl γ, γ-dichlorocrotonate	16.6	1.2323	1.46096	1.46347	1.47098	1.47711	(86)
$C_6H_8N_2$	2, 5-Dimethylpyrazine	23.6	0.9856	1.49457	1.49921	1.51202	1.52372	(106)
$C_6H_8N_2$	*m*-Phenylenediamine	57.7	1.10696	1.62558	1.63390	1.65600	1.67617	(161)
$C_6H_8N_2$	Phenylhydrazine	17.7	1.0983	1.60201	1.60926*	1.62761	1.64412	(29,† 106)
$C_6H_8N_2O_3$	Methyl ethyloximinocyanoacetate	20	1.1240	1.4538	1.4578	1.4677	1.4769	(152)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_6H_8N_2O_3$	Ethyl methyloximinocyanoacetate	20	1.1255	1.4527	1.4565	1.4664	1.4753	(152)
C_6H_8O	1, 4-Dimethylfurane	17.7	0.9026	1.43959	1.44270	1.45124	1.45832	(157)
C_6H_8O	α, α-Dimethylfurfuran	21.6	0.8871	1.43173	1.43508	1.44313	1.45008	(41)
C_6H_8O	Methyl-α-pyran	17.7	0.9187	1.45108	1.45421	1.46265	1.46977	(23)
$C_6H_8O_2$	β-Methyl-Δ′-angelolactone	16.2	1.0602	1.46393	1.46740*	1.47566	1.48285	(28)
$C_6H_8O_4$	Dimethyl maleate	20	1.1517	1.43863	1.44150	1.44901	1.45528	(45,† 144)
$C_6H_8O_4$	Monoethyl fumarate	83	1.1149	1.43818	1.44088	1.45024		(49)
C_6H_8S	α, α′-Dimethylthiophene	13.4	0.9906	1.51233	1.51693*	1.52839	1.53842	(59,† 157)
C_6H_8S	β, β′-Dimethylthiophene	15	0.9932	1.51752	1.52217*	1.53339	1.54320	(59)
C_6H_8S	α-Ethylthiophene	21.2	0.9908	1.50834	1.51273	1.52359	1.53310	(59)
$C_6H_9BrO_3$	Ethyl α-bromoacetoacetate	14.05	1.4294	1.46081	1.46337	1.47066	1.47665	(34)
$C_6H_9BrO_3$	Ethyl γ-bromoacetoacetate	18.1	1.5276	1.48020	1.48311	1.49149	1.49834	(34)
$C_6H_9ClN_2$	1, 3, 4-Trimethyl-5-chloropyrazole	20	1.1082	1.48368	1.48718*	1.49564	1.50299	(38)
C_6H_9ClO	α, β-Isohexenoyl chloride	14.2	1.0235	1.45994	1.46396*	1.47348	1.48185	(69)
C_6H_9ClO	β, γ-Hexenoyl chloride	19.6	1.0142	1.44405	1.44730*	1.45455	1.46038	(69)
$C_6H_9ClO_2$	Ethyl α-chlorocrotonate	14.3	1.1073	1.45246	1.45580	1.46367	1.47063	(69)
$C_6H_9ClO_2$	Ethyl β-chlorocrotonate	19.2	1.1018	1.45639	1.45985	1.46836	1.47538	(69)
$C_6H_9ClO_2$	Ethyl α-chloroisocrotonate	18.0	1.1021	1.45068	1.45391*	1.46171	1.46868	(69,† 126)
$C_6H_9ClO_2$	Ethyl β-chloroisocrotonate	14.4	1.0920	1.45317	1.45679	1.46561	1.47345	(69,† 126)
C_6H_9N	1, 4-Dimethylpyrrole	19.8	0.9353	1.50049	1.50357	1.51504	1.52469	(157)
C_6H_9N	2, 4-Dimethylpyrrole	13.7	0.9273	1.49536	1.49942*	1.50947	1.51828	(60)
C_6H_9N	2, 5-Dimethylpyrrole	16.8	0.9393	1.50354	1.50783*	1.51828	1.52750	(60)
C_6H_9N	β, γ-Hexenonitrile	18	0.8424	1.43023	1.43313	1.43980	1.44557	(69)
C_6H_9N	α, β-Isohexenonitrile	18.8	0.8556	1.43529	1.43796	1.44529	1.45129	(58,† 69)
C_6H_9NO	Trimethylisoxazole	14.5	0.9862	1.45118	1.45420	1.46150	1.46782	(31)
C_6H_{10}	Cyclohexene	15.1	0.8147	1.44653	1.44921	1.45620	1.46194	(55, 104)
C_6H_{10}	Diallyl	20	0.6880	1.39812	1.40102	1.40793	1.41385	(92)
C_6H_{10}	Diisopropenyl	15	0.73074	1.4379	1.4421	1.4527	1.4622	(43)
C_6H_{10}	2, 4-Hexadiene	12.5	0.72732	1.45133	1.45591	1.46800	1.47855	(43, 121)
C_6H_{10}	Tetrahydrobenzene	22.1	0.8081	1.44235	1.44507	1.45184	1.45743	(104)
$C_6H_{10}N_2$	1-Ethyl-3-methylpyrazole	14.9	0.9491	1.47113	1.47472*	1.48292	1.49008	(60)
$C_6H_{10}N_2$	1, 3, 4-Trimethylpyrazole	22.5	0.9494	1.47145	1.47495*	1.48334	1.49061	(60)
$C_6H_{10}N_2$	1, 3, 5-Trimethylpyrazole	37.5	0.9304	1.46526	1.46865*	1.47678	1.48409	(60)
$C_6H_{10}O$	Anhydro-δ-acetobutyl alcohol	16.2	0.9088	1.44535	1.44830*	1.45503	1.46091	(28)
$C_6H_{10}O$	Allylacetone	15.4	0.8470	1.41856	1.42126	1.42778	1.43327	(71,† 125)
$C_6H_{10}O$	Diethylketene	14.85	0.8338	1.41108	1.41355	1.41991		(18)
$C_6H_{10}O$	Cyclohexanone	16.8	0.9487	1.45004	1.45242	1.45834	1.46346	(55)
$C_6H_{10}O$	α-Methyl-β-ethylacrolein	14	0.8605	1.44427	1.44808	1.45761	1.46542	(43)
$C_6H_{10}O$	Mesityl oxide	20	0.8578	1.44028	1.44397	1.45352	1.46192	(43,† 95)
$C_6H_{10}O_2$	Acetonylacetone	17.0	0.9834	1.42167	1.42395		1.43431	(105)
$C_6H_{10}O_2$	Propionylacetone	14.9	0.9639	1.44977	1.45391	1.46577	1.47686	(56)
$C_6H_{10}O_2$	Hydroxymethylenediethylketone	48.9	0.9653	1.45375	1.45792	1.46955	1.47926	(17)
$C_6H_{10}O_2$	Methylacetylacetone	13.5	0.9775	1.43537	1.43804	1.44596	1.45265	(17,† 56)
$C_6H_{10}O_2$	Acetylacetone *O*-methyl ether	15.9	0.9744	1.46620	1.47068	1.48267	1.49367	(17)
$C_6H_{10}O_2$	Cyclopentylcarboxylic acid	15.5	1.0555	1.45329		1.46142	1.46609	(130)
$C_6H_{10}O_2$	α-Ethylcrotonic acid	56.1	0.9484	1.44022	1.44260*	1.45102	1.45842	(69)
$C_6H_{10}O_2$	α, β-Hexenic acid	40	0.9490	1.44360	1.44666*	1.45538	1.46287	(69)
$C_6H_{10}O_2$	α, β-Isohexenic acid	16.0	0.9589	1.44706	1.45060*	1.45931	1.46689	(69)
$C_6H_{10}O_2$	Ethyl crotonate	20	0.9237	1.42189	1.42495	1.43240	1.43872	(43,† 94, 95)
$C_6H_{10}O_2$	Ethyl isocrotonate	19.6	0.9246	1.42256	1.42590*	1.43285	1.43974	(69)
$C_6H_{10}O_2$	Methyl β, β-dimethylacrylate	19.8	0.9337	1.42901	1.43207	1.43985	1.44663	(43)
$C_6H_{10}O_3$	δ-Methoxy-γ-valerolactone	23.2	1.1200	1.44313	1.44533	1.45076	1.45540	(80)
$C_6H_{10}O_3$	Ethyl acetoacetate	16.6	1.0320	1.41851	1.42092	1.42660	1.43155	(93, 123†)
$C_6H_{10}O_3$	Ethyl α-hydroxymethylenepropionate	16.1	1.0268	1.42559	1.42876	1.43602	1.44269	(17)
$C_6H_{10}O_3$	Methyl α, β-butyleneoxide-δ-carboxylate	24.7	1.0726	1.42380	1.42589	1.43107	1.43545	(80)
$C_6H_{10}O_3$	Methyl methylacetoacetate	23.8	1.0304	1.41416	1.41629	1.42184	1.42648	(9)
$C_6H_{10}O_4$	Diethyl oxalate	20	1.0793	1.40824	1.41043	1.41564	1.41987	(18, 93†)
$C_6H_{10}O_4$	Dimethyl succinate	18.3	1.1202	1.41774	1.41976		1.42868	(105)
$C_6H_{10}O_4$	Methyl hydrogen pyrotartrate	20.7	1.1436	1.43006	1.43230	1.43764	1.44195	(102)
$C_6H_{10}S$	Allyl sulfide	26.8	0.8876	1.48384	1.48770	1.49787	1.50637	(160)
$C_6H_{11}ClO_2$	Ethyl chlorobutyrate	20	1.0517	1.42231	1.42458	1.42990	1.43434	(93)
$C_6H_{11}N$	Capronitrile	14.3	0.8069	1.40647	1.40851		1.41739	(106)
$C_6H_{11}NO$	Mesityloxime	21.0	0.9417	1.48655	1.49083	1.50219	1.51209	(106)
$C_6H_{11}NO$	α-Mesityl oxide oxime	14.5	0.9494	1.48521	1.48961*	1.50021	1.50962	(74)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_6H_{11}NO_2$	Ethyl β-aminocrotonate	18.8	1.0219	1.49479	1.50067	1.51647	1.53160	(105,106, 126)
$C_6H_{11}NO_3$	Ethyl dimethyloxamate	22.5	1.0735	1.43880	1.44144	1.44830	1.45389	(109)
C_6H_{12}	Cyclohexane	10.85	0.7872	1.42910	1.43119	1.43668	1.44116	(55)
C_6H_{12}	Hexylene	23.3	0.6792	1.39196	1.39446	1.40071	1.40590	(104,† 148)
$C_6H_{12}N_2$	Dimethylketazine	24.5	0.8381	1.44746	1.45102	1.46008	1.46805	(109)
$C_6H_{12}N_2$	Propylglyoxalidine	17.0	0.9641	1.48383	1.48708	1.49518	1.50206	(109)
$C_6H_{12}N_2O_4$	Methyl *n*-butylnitrocarbamate	22.0	1.1396	1.44561	1.44859	1.45609	1.46249	(109)
$C_6H_{12}N_2O_4$	Methyl isobutylnitrocarbamate	21 9	1.1346	1.44315	1.44614	1.45354	1.45996	(109)
$C_6H_{12}N_2O_4$	Methyl *sec.*-butylnitrocarbamate	23.3	1.1248	1.43879	1.44167	1.44895	1.45532	(109)
$C_6H_{12}O$	2-Hexen-4-ol	16.7	0.84697	1.43417	1.43688	1.44370	1.44948	(121)
$C_6H_{12}O$	Cyclohexanol	22.6	0.9463	1.46330	1.46560	1.47141	1.47623	(55)
$C_6H_{12}O$	Ethyl propyl ketone	22	0.81491	1.39683	1.39899	1.40402	1.40813	(125)
$C_6H_{12}O$	Methyl isobutyl ketone	17.4	0.80316	1.39500	1.39694	1.40235	1.40638	(125)
$C_6H_{12}O_2$	δ-Acetobutyl alcohol	15.4	0.9943	1.44937	1.45180*	1.45752	1.46234	(28)
$C_6H_{12}O_2$	Caproic acid	19.6	0.9220	1.41235	1.41449	1.41964	1.42397	(125,† 147)
$C_6H_{12}O_2$	Amyl formate	11.5	0.8832	1.3910	1.3951	1.4000	1.4084	(132)
$C_6H_{12}O_2$	Ethyl butyrate	18	0.8797	1 39099	1.39302	1.39778	1.40166	(94, 134)
$C_6H_{12}O_2$	Isobutyl acetate	17.8	0.87306	1.38905	1.39114	1.39597	1.39994	(125)
$C_6H_{12}O_3$	Paraldehyde	20	0.9943	1.40304	1.40486	1.40948	1.41302	(93)
$C_6H_{12}O_4$	Methyl α, α-dimethoxypropionate	17.6	1.0678	1.41035	1.41221	1.41721	1.42130	(5)
$C_6H_{13}N$	α-Methylpiperidine	23.6	0.8436	1.44384	1.44639		1.45769	(106)
$C_6H_{13}N$	β-Methylpiperidine	24.3	0.8446	1.44380	1.44627		1.45760	(106)
$C_6H_{13}N$	γ-Methylpiperidine	21.6	0.8184	1.43516	1.43779		1.44951	(106)
$C_6H_{13}N$	Propylpropylideneamine	17.5	0.7604	1.41032	1.41269	1.41878	1.42380	(109)
$C_6H_{13}NO_2$	Methyl *n*-butylcarbamate	23.3	0.9689	1.42647	1.42888	1.43448	1.43906	(109)
$C_6H_{13}NO_2$	Methyl isobutylcarbamate	21.6	0.9651	1.42509	1.42750	1.43300	1.43765	(109)
$C_6H_{13}NO_2$	Methyl *sec.*-butylcarbamate	24.9	0.9651	1.42380	1.42625	1.43168	1 43616	(109)
C_6H_{14}	Hexane	20	0.6603	1.37337	1.37536	1.37988	1.38365	(92, 148)
$C_6H_{14}N_2O_2$	*N*-Hexylnitroamine	25.2	1.0037	1.45610	1.45931	1.46733	1.47410	(109)
$C_6H_{14}O_2$	Acetal	20	0.8314	1.38000	1.38193	1.38636	1.39007	(93)
$C_6H_{15}N$	Dipropylamine	19.5	0.7384	1.40242	1.40455		1.41453	(106)
$C_6H_{15}N$	Triethylamine	20	0.7277	1.39804	1.40032	1.40613	1.41092	(92, 106)
$C_6H_{15}N_3$	Triformalmethylamine	19.0	0.9178	1.46039	1.46320	1.47047	1.47653	(109)
$C_6H_{15}O_2P$	Diethyl ethylphosphinate	10	1.0259	1.41434	1.41627	1.42107	1.42524	(2)
$C_6H_{15}O_3P$	Diethyl phosphite	10	0.9687	1.41073	1.41309	1.41917	1.42423	(2)
$C_6H_{15}O_4P$	Triethyl phosphate	10	1.0682	1.40436	1.40616	1.41073	1.41449	(2)
C_7H_5ClO	*o*-Chlorobenzaldehyde	21.7	1.2474	1.55972	1.56564	1.58274	1.59807	(47)
C_7H_5ClO	*m*-Chlorobenzaldehyde	20.2	1.2410	1.55908	1.56500	1.58184	1.59702	(47)
C_7H_5ClO	*p*-Chlorobenzaldehyde	61.0	1.1958	1.54878	1.55525	1.57341		(47)
C_7H_5ClO	Benzoyl chloride	20	1.2122	1.54751	1.55369	1.56964	1.58411	(80, 95†)
C_7H_5N	Benzonitrile	25.5	1.0003	1.52035	1.52570	1.53942	1.55144	(106)
C_7H_5NO	Anthranil	14.9	1.1866	1.57891	1.58676*	1.60778	1.62923	(29,† 117, 118)
C_7H_5NO	Indoxazene	15.9	1.1744	1.55824	1.56446*	1.58012	1.59448	(31)
C_7H_5NO	Phenyl isocyanate	19.6	1.0956	1.53139	1.53684	1.55082	1.56303	(106)
C_7H_5NS	Phenyl isothiocyanate	23.4	1.1289	1.63959	1.64918	1.67513	1.69938	(158, 159)
C_7H_6O	Benzaldehyde	17.6	1.0492	1.53948	1.54629	1.56283	1.57731	(43)
$C_7H_6O_2$	Salicylaldehyde	19.7	1.1671	1.56526	1.57358	1.59674	1.62097	(41)
C_7H_7BrO	*o*-Bromoanisole	20	1.5018	1.56690	1.57245	1.58695		(91)
C_7H_7BrO	*p*-Bromoanisole	20	1.4569	1.55507	1.56051	1.57462		(91)
C_7H_7BrS	*o*-Bromophenyl methyl sulfide	20	1.5216	1.62495	1.63190	1.65020		(91)
C_7H_7Cl	*o*-Chlorotoluene	20.2	1.0795	1.52040	1.52466	1.53700	1.54739	(47)
C_7H_7Cl	*m*-Chlorotoluene	18.7	1.0760	1.51822	1.52252	1.53473	1.54505	(47)
C_7H_7Cl	*p*-Chlorotoluene	24.35	1.0651	1.51504	1.51925	1.53146	1.54158	(47)
C_7H_7Cl	Benzyl chloride	15.4	1.1138	1.5367	1.5415	1.5542	1.5652	(140)
C_7H_7I	*o*-Iodotoluene	15.9	1.7192	1.60400	1.61066	1.62742		(47)
C_7H_7NO	α-Benzaldoxime	13.8	1.1160	1.58767	1.59558*	1.61544	1.63345	(74, 106)
$C_7H_7NO_2$	*o*-Nitrotoluene	20.4	1.1625	1.54104	1.54739		1.57933	(106)
$C_7H_7NO_3$	*o*-Nitroanisole	20	1.2527	1.55468	1.56188	1.58289		(91)
$C_7H_7NO_3$	*p*-Nitroanisole	60	1.2192	1.56385	1.57072	1.59262		(91)
C_7H_8	Toluene	16.35	0.8684	1.49365	1.49782	1.50967	1.51970	(20,† 92, 132, 134, 148)
$C_7H_8N_2O$	Nitrosomethylaniline	22.7	1.1213	1.56832	1.57602		1.61585	(106)
C_7H_8O	Benzyl alcohol	20	1.0429	1.53474	1.53955	1.55178	1.56232	(92,† 131)
C_7H_8O	*m*-Cresol	18	1.0363	1.53756	1.54246	1.55590	1.56727	(145)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
C_7H_8O	Anisole	16.5	0.9989	1.51482	1.51950	1.53235	1.54338	(47, 91, 145,† 155, 156)
C_7H_8OS	α-Methyl-α′-acetothienone	24.7	1.1185	1.55329	1.56038*	1.57900	1.59760	(59)
C_7H_8OS	α-Propiothienone	15.0	1.1361	1.55148	1.55776*	1.57400	1.58949	(59)
$C_7H_8O_2S$	Ethyl α-thiophenecarboxylate	16.3	1.1623	1.52181	1.52719*	1.54046	1.55273	(59)
$C_7H_8O_3$	Methyl salicylate	18.1	1.1855	1.53149	1.53773	1.55371	1.56921	(41)
$C_7H_9Cl_3O_3$	Methyl γ, γ, γ-trichloro-β-acetylbutyrate	14.5	1.3935	1.46560	1.46815	1.47423	1.47947	(81)
C_7H_9N	Benzylamine	19.5	0.9827	1.53918	1.54406	1.55670	1.56753	(106)
C_7H_9N	β-Ethylpyridine	22.5	0.9401	1.49783	1.50214		1.52217	(106)
C_7H_9N	Methylaniline	21.2	0.9851	1.56348	1.57021	1.58823	1.60322	(106)
C_7H_9N	*o*-Toluidine	20	0.9986	1.56650	1.57276	1.58945	1.60425	(92, 106,† 145)
C_7H_9N	*m*-Toluidine	22.4	0.9962	1.56473	1.57106		1.60267	(106)
C_7H_9N	*p*-Toluidine	59.1	0.9538	1.54710	1.55324		1.58351	(106)
C_7H_9NO	*o*-Anisidine	20	1.0923	1.56884	1.57536	1.59235		(91)
C_7H_9NO	*p*-Anisidine	67	1.0605	1.54938	1.55592	1.57244		(91)
C_7H_9NO	1-Cyanocyclohexan-2-one	15.9	1.0741	1.47689	1.47932*	1.48623	1.49156	(39)
C_7H_9NO	β, γ-Tetrahydrobenzisoxazole	17.2	1.0996	1.49631	1.49953*	1.50714	1.51381	(31)
$C_7H_9NO_2$	Furylimido ethyl ether	17.8	1.0782	1.48842	1.49297	1.50451	1.51508	(109)
$C_7H_9NO_2$	Ethyl α-cyanocrotonate	18.8	1.0255	1.44988	1.45302	1.46172	1.46888	(58)
$C_7H_9NO_3$	Ethyl α-cyanoacetoacetate	20	1.1107	1.4669	1.4710	1.4816	1.4905	(138)
C_7H_9NS	*o*-Aminophenylmethyl sulfide	17	1.1333	1.61879	1.62632	1.64659		(91)
C_7H_{10}	1, 3, 5-Heptatriene	19.8	0.7636	1.50786	1.51604	1.53754	1.55742	(27)
$C_7H_{10}N_2$	*asym.*-Methylphenylhydrazine	19.7	1.0404	1.57630	1.58316*	1.62761	1.64412	(29,† 106)
$C_7H_{10}N_2$	*sym.*-Methylphenylhydrazine	23.1	1.0296	1.56501	1.57146*	1.60111	1.61757	(29)
$C_7H_{10}N_2O_3$	Ethyl ethyloximinocyanoacetate	20	1.0818	1.4494	1.4530	1.4624	1.4710	(152)
$C_7H_{10}O$	1-Methyl-1-cyclohexen-3-one	18.7	0.9707	1.49137	1.49547	1.50624	1.51573	(44)
$C_7H_{10}O_2$	Δ¹-Tetrahydrobenzoic acid	47.0	1.0719	1.48576	1.49023*	1.49882	1.50705	(26)
$C_7H_{10}O_2$	γ-Acetoxyvalerolactone	78.6	1.1231	1.42111	1.42355	1.42862	1.43292	(49)
$C_7H_{10}O_2$	α, α-Dimethylangelolactone	13.7	0.9818	1.43314	1.43593	1.44247	1.44820	(28)
$C_7H_{10}O_2$	Hydroxymethylene-1-cyclohexan-2-one	20.5	1.0848	1.50697	1.51218	1.52774		(17, 56)
$C_7H_{10}O_2$	Ethyl β-vinylacrylate	22.9	0.9351	1.46948	1.47504*	1.48928	1.50252	(27)
$C_7H_{10}O_3$	Ethyl β-acetylacrylate	18.1	1.0387	1.44987	1.45346*	1.46250	1.47081	(27)
$C_7H_{10}O_4$	Ethyl acetonoxalate	17.6	1.1275	1.46976	1.47498		1.50054	(105)
$C_7H_{10}O_4$	Ethyl acetoxymethyleneacetate	18.1	1.0905	1.44382	1.44742	1.45601	1.46382	(17)
$C_7H_{10}O_4$	Ethyl hydroxymethyleneacetoacetate	16.9	1.1338	1.46925	1.47376	1.48565	1.49673	(17)
$C_7H_{10}O_4$	Dimethyl citraconate	20	1.1104	1.44455	1.44759	1.45551	1.46218	(45,† 144)
$C_7H_{10}O_4$	Dimethyl itaconate	20	1.1218	1.44126	1.44412	1.45099	1.45685	(144)
$C_7H_{10}O_4$	Dimethyl mesaconate	20	1.12097	1.45217	1.45568	1.46453	1.47225	(45,† 144)
$C_7H_{10}O_5$	Diethyl oxomalonate	15.6	1.1419	1.41626	1.41865	1.42439		(18)
$C_7H_{11}ClO$	α, β-Isoheptenyl chloride	17.1	0.9940	1.45887	1.46259*	1.47202	1.48011	(69)
$C_7H_{11}ClO_4$	Diethyl chloromalonate	19.3	1.2047	1.43299	1.43527		1.44568	(105)
$C_7H_{11}N$	α, β-Isoheptenonitrile	12	0.8286	1.44020	1.44346*	1.45132	1.45807	(58, 69†)
$C_7H_{11}N$	Δ²-Isoheptenonitrile	22.3	0.8241	1.42691	1.42932	1.43614	1.44166	(58)
$C_7H_{11}N$	2, 3, 5-Trimethylpyrrole	15.8	0.9351	1.50474	1.50888*	1.51892	1.52745	(60)
C_7H_{12}	2, 4-Dimethyl-2, 4-pentadiene	17.3	0.7412	1.43663	1.44055	1.45006	1.45842	(43)
C_7H_{12}	1-Heptine	20	0.7458	1.41822	1.42073	1.42690	1.43212	(95,† 150)
C_7H_{12}	Methenecyclohexane	16.4	0.8021	1.44863	1.45182	1.45879	1.46488	(46,† 55)
C_7H_{12}	1-Methyl-1-cyclohexene	18.5	0.8115	1.44744	1.45033	1.45711	1.46293	(46)
$C_7H_{12}Br_2O_2$	Ethyl α, β-dibromovalerate	15.4	1.6199	1.49527	1.49863*	1.50656	1.51332	(69)
$C_7H_{12}N_2$	1, 3, 4, 5-Tetramethylpyrazole	23.4	0.9442	1.47634	1.47974*	1.48811	1.49528	(60)
$C_7H_{12}O$	Allylpropenyl carbinol	20	0.8612	1.45089	1.45414*	1.46191	1.46840	(27)
$C_7H_{12}O$	Cycloheptanone	21.9	0.9495	1.45801	1.46027	1.46646	1.47149	(55)
$C_7H_{12}O$	1-Methylcyclohexan-2-one	14.6	0.9300	1.44827	1.45049	1.45653	1.46135	(55)
$C_7H_{12}O$	1-Methylcyclohexan-3-one	25.15	0.9139	1.44092	1.44313	1.44914	1.45394	(55)
$C_7H_{12}O$	1-Methylcyclohexan-4-one	24.4	0.9119	1.44092	1.44322	1.44918	1.45413	(55,† 61)
$C_7H_{12}O_2$	Dimethylacetylacetone	27.8	0.9496	1.42386	1.42615	1.43183	1.43663	(17)
$C_7H_{12}O_2$	Ethylacetylacetone	16.9	0.9560	1.43667	1.43968	1.44736	1.45447	(17,† 56)
$C_7H_{12}O_2$	Hydroxymethylenemethyl-*tert.*-butyl ketone	20.15	0.9347	1.44834	1.45263	1.46377	1.47449	(17)
$C_7H_{12}O_2$	Acetylacetone *O*-ethyl ether	16.3	0.9477	1.46204	1.46648	1.47759	1.48790	(17)
$C_7H_{12}O_2$	Cyclopentylacetic acid	34.0	1.0083	1.44579		1.45378	1.45838	(130)
$C_7H_{12}O_2$	Cyclohexylcarboxylic acid	33.8	1.0253	1.45382		1.46197	1.46666	(130)
$C_7H_{12}O_2$	α, β-Isoheptenic acid	15.3	0.9458	1.45118	1.45460*	1.46328	1.47034	(69)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_7H_{12}O_2$	Δ²-Isoheptenic acid	17.2	0.9430	1.44274	1.44569	1.45354	1.46017	(58)
$C_7H_{12}O_2$	α-Methyl-Δ²-hexenic acid	13.45	0.9477	1.43980	1.44246	1.44945	1.45512	(53)
$C_7H_{12}O_2$	γ-Methyl-Δ²-hexenic acid	14.2	0.9706	1.45027	1.45290	1.46001	1.46601	(53)
$C_7H_{12}O_2$	Ethyl angelate	19.5	0.9178	1.42781	1.43102*	1.43802	1.44435	(69)
$C_7H_{12}O_2$	Ethyl *β*, *β*-dimethylacrylate	15.0	0.9171	1.43335	1.43679*	1.44462	1.45177	(69)
$C_7H_{12}O_2$	Ethyl *α*, *β*-pentenate	21.9	0.9072	1.42737	1.43047*	1.43788	1.44422	(69)
$C_7H_{12}O_2$	Ethyl tiglate	19.5	0.9247	1.43236	1.43554*	1.44290	1.44927	(69)
$C_7H_{12}O_3$	δ-Ethoxy-γ-valerolactone	24.9	1.0715	1.43860	1.44082	1.44621	1.45089	(80)
$C_7H_{12}O_3$	Ethyl α-ethoxyacrylate	17.2	0.9956	1.42941	1.43241	1.43925	1.44536	(5)
$C_7H_{12}O_3$	Ethyl β-ethoxyacrylate	16.7	0.9965	1.44497	1.44852	1.45765	1.46574	(5)
$C_7H_{12}O_3$	Ethyl methylacetoacetate	17.8	1.0010	1.41876	1.42066	1.42671	1.43154	(9,† 105)
$C_7H_{12}O_3$	Methyl dimethylacetoacetate	16.8	1.0122	1.41946	1.42166	1.42701	1.43145	(9,† 105)
$C_7H_{12}O_3$	Ethyl levulinate	16.2	1.0168	1.42192	1.42416	1.42955	1.43415	(6)
$C_7H_{12}O_3$	Methyl cyclopentan-1-ol-1-carboxylate	17.0	1.1047	1.45445	1.45672	1.46237	1.46707	(63)
$C_7H_{12}O_4$	Diethyl malonate	17.2	1.0570	1.41255	1.41508	1.41977	1.42395	(9,† 105)
$C_7H_{12}O_4$	Dimethyl dimethylmalonate	24.2	1.0589	1.41106	1.41312	1.41816	1.42219	(9)
$C_7H_{12}O_4$	Dimethyl pyrotartrate	19.6	1.0692	1.41841	1.42042		1.42939	(102)
$C_7H_{12}O_4$	Ethyl hydrogen pyrotartrate	20.2	1.0982	1.42899	1.43121		1.44066	(102)
$C_7H_{14}N_2$	Dipropylcarbimide	23.0	0.8381	1.44253	1.44541	1.45244	1.45830	(106)
$C_7H_{14}N_2$	Dipropylcyanamide	24.4	0.8572	1.42744	1.42979	1.43537	1.44006	(106)
$C_7H_{14}N_2O_4$	Ethyl *n*-butylnitrocarbamate	20.7	1.0985	1.44256	1.44546	1.45270	1.45887	(109)
$C_7H_{14}N_2O_4$	Ethyl isobutylnitrocarbamate	20.5	1.0941	1.44043	1.44331	1.45052	1.45683	(109)
$C_7H_{14}N_2O_4$	Ethyl *sec.*-butylnitrocarbamate	21.4	1.0861	1.43685	1.43972	1.44681	1.45287	(109)
$C_7H_{14}O$	Butenyldimethyl carbinol	16.2	0.83822	1.43192	1.43446	1.44082	1.44622	(125)
$C_7H_{14}O$	1-Methylcyclohexan-1-ol	24.65	0.9251	1.45631	1.45874	1.46428	1.46908	(55)
$C_7H_{14}O$	1-Methylcyclohexan-2-ol	13.4	0.9333	1.46352	1.46585	1.47180	1.47665	(55)
$C_7H_{14}O$	1-Methylcyclohexan-3-ol	24.4	0.9152	1.45497	1.45734	1.46319	1.46819	(55)
$C_7H_{14}O$	1-Methylcyclohexan-4-ol	20.7	0.9175	1.45595	1.45833	1.46406	1.46897	(55,† 61)
$C_7H_{14}O$	5-Methyl-1-hexen-5-ol	16.2	0.8382	1.43194	1.43446	1.44082	1.44622	(71)
$C_7H_{14}O$	Oenanthyl aldehyde	20	0.8495	1.42339	1.42571	1.43094	1.43514	(93)
$C_7H_{14}O$	Dipropyl ketone	21.7	0.8160	1.40521	1.40732		1.41650	(105)
$C_7H_{14}O_2$	Cycloacetobutyl methyl ether	16.7	0.9485	1.42629	1.42830*	1.43324	1.43742	(28)
$C_7H_{14}O_2$	Heptylic acid	19.8	0.91846	1.41932	1.42162	1.42682	1.43132	(125,† 130, 147)
$C_7H_{14}O_2$	Ethyl isovalerate	18.8	0.86840	1.39520	1.39671	1.40203	1.40605	(125)
$C_7H_{14}O_2$	Isoamyl acetate	17.9	0.87450	1.39958	1.40170	1.40658	1.41072	(125,† 134)
$C_7H_{15}N$	β-Ethylpiperidine	23.2	0.8565	1.45058	1.45310		1.46449	(106)
$C_7H_{15}N$	γ-Ethylpiperidine	18.9	0.8260	1.44192	1.44450	1.45103	1.45647	(106)
$C_7H_{15}N$	γ-Dimethylpiperidylamine	19.2	0.7585	1.41940	1.42203	1.42890	1.43466	(106)
$C_7H_{15}NO$	Dipropylketoxime	24.1	0.8877	1.44456	1.44724		1.45914	(106)
$C_7H_{15}NO_2$	Ethyl *n*-butylcarbamate	25.6	0.9434	1.42552	1.42784	1.43339	1.43784	(109)
$C_7H_{15}NO_2$	Ethyl isobutylcarbamate	26.7	0.9386	1.42302	1.42530	1.43087	1.43534	(109)
$C_7H_{15}NO_2$	Ethyl *sec.*-butylcarbamate	26.0	0.9404	1.42430	1.42666	1.43214	1.43652	(109)
C_7H_{16}	Heptane	23	0.6809	1.3826	1.3867	1.3917	1.3991	(132)
$C_7H_{16}O$	*n*-Heptyl alcohol	22.4		1.42116	1.42326	1.42843	1.43281	(131)
$C_7H_{16}O_3$	Triethyl orthoformate	18.8	0.8971	1.39034	1.39218	1.39676	1.40044	(108)
$C_8H_4Cl_2O_2$	Phthalyl chloride	15.5	1.4077	1.56505	1.57099	1.45676	1.60116	(80,† 95)
$C_8H_4Cl_2O_2$	Isophthalyl chloride	46.9	1.3872	1.56336	1.56999	1.58672	1.60236	(80)
C_8H_6	Phenylacetylene	12.5	0.9371	1.54604	1.5524	1.57986	1.59856	(150)
$C_8H_6N_2$	Quinoxaline	48.0	1.1334	1.61428	1.62311	1.64858	1.67341	(109)
C_8H_6O	Coumarone	22.7	1.0913	1.55787	1.56450	1.58101	1.59609	(41)
$C_8H_6O_2$	*o*-Hydroxyphenylacetic acid lactone	15.4	1.2220	1.54781	1.55337	1.56552	1.57667	(19)
$C_8H_6O_2$	Phthalide	99.1	1.1636	1.53021	1.53560	1.54896		(49)
C_8H_6S	Thionaphthene	36.2	1.1484	1.62509	1.63324	1.65439	1.67386	(41)
C_8H_7N	Benzyl cyanide	20.2	1.0176	1.51977	1.52422		1.54552	(106)
C_8H_7N	*o*-Tolunitrile	23.1	0.9896	1.52200	1.52720		1.55228	(106)
C_8H_7NO	Methylanthranil	19.95	1.1334	1.57019	1.57795	1.60005	1.62206	(117, 118†)
C_8H_8	Cinnamene	21	0.9111	1.5318	1.5446	1.5615	1.5936	(132)
C_8H_8	Styrene	17	0.90595	1.53699	1.54344	1.56036	1.57588	(14, 43,† 155, 156)
$C_8H_8Cl_2O$	*o*-Methyldichloromethylketodihydrobenzene	44	1.2573	1.52275	1.52908	1.54159	1.55792	(52)
$C_8H_8Cl_2O$	*p*-Methyldichloromethylketodihydrobenzene	51		1.53141	1.53644	1.54779	1.55832	(52)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_8H_8Cl_2O$	1-Methyl-1-dichloromethyl-3, 5-cyclohexadien-2-one	33.5	1.2700	1.52766	1.53284	1.54660		(45)
$C_8H_8Cl_2O$	1-Methyl-1-dichloromethyl-4-keto-2, 5-cyclohexadiene	51		1.53141	1.53644	1.54779	1.55832	(45)
$C_8H_8N_2$	Methylmethenyl-*o*-phenylenediamine	17.1	1.1283	1.59454	1.60133	1.61906	1.63498	(109)
C_8H_8O	Coumarane	13.3	1.0800	1.54485	1.54997	1.56374	1.57572	(16)
C_8H_8O	*o*-Hydroxystyrene	35.7	1.0466	1.56997	1.57724	1.59661	1.61474	(14)
C_8H_8O	Phenylacetaldehyde	19.6	1.0272	1.52056	1.52546	1.53738	1.54783	(43)
C_8H_8O	*o*-Toluic aldehyde	19.0	1.0386	1.54233	1.54852	1.56502	1.57978	(41)
C_8H_8O	*m*-Toluic aldehyde	21.4	1.0189	1.53444	1.54068	1.55676	1.57168	(41)
C_8H_8O	*p*-Toluic aldehyde	16.6	1.0195	1.54015	1.54693	1.56413	1.58000	(8, 41)
C_8H_8O	Acetophenone	19.1	1.0293	1.52832	1.53427	1.55003	1.56103	(43,† 44, 105, 145)
$C_8H_8O_2$	Anisaldehyde	12.7	1.1302	1.56784	1.57641	1.59764		(41)
$C_8H_8O_2$	*p*-Homosalicylaldehyde	59.2	1.0913	1.53921	1.54655	1.56840		(41)
$C_8H_8O_2$	*m*-Methoxybenzaldehyde	13.9	1.1245	1.55006	1.55656	1.57486	1.59228	(41)
$C_8H_8O_2$	*o*-Hydroxyacetophenone	21.3	1.1303	1.55061	1.55797	1.57821	1.59931	(41)
$C_8H_8O_2$	Salicylaldehyde methyl ether	20.2	1.1326	1.55245	1.55966	1.57947	1.59912	(41)
$C_8H_8O_2$	Methyl benzoate	16.0	1.0905	1.51309	1.51810	1.53060	1.54157	(43, 44†)
$C_8H_8O_3$	Methyl salicylate	21		1.5206	1.5319	1.5241	1.5810	(134)
$C_8H_8O_4$	Ethyl coumalate	39.2	1.2094	1.50176	1.50655	1.52081	1.53396	(23)
C_8H_9Br	*asym.*-Bromo-*o*-xylene	18.4	1.3708	1.55240	1.55712	1.57058	1.58194	(47)
C_8H_9Br	Bromo-*p*-xylene	18.5	1.3582	1.54676	1.55138	1.56467	1.57589	(47)
C_8H_9I	*asym.*-Iodo-*o*-xylene	18.35	1.6334	1.59884	1.60490	1.62163		(47)
C_8H_9I	*vic.*-Iodo-*o*-xylene	19.75	1.6395	1.60131	1.60736	1.62372		(47)
C_8H_9I	*asym.*-Iodo-*m*-xylene	16.3	1.6282	1.59436	1.60080	1.61687		(47)
C_8H_9I	*sym.*-Iodo-*m*-xylene	18.5	1.6085	1.59082	1.59672	1.61312		(47)
C_8H_9I	Iodo-*p*-xylene	17.4	1.6168	1.59273	1.59917	1.61508		(47)
C_8H_9NO	α-Benzaldoxime Ȯ-methyl ether	17.0	1.0227	1.54311	1.55001*	1.56798	1.58494	(74)
$C_8H_9NO_2$	*aci*-Phenylnitromethane methyl ether	15.0	1.1241	1.57895	1.58708*	1.60751	1.62445	(74)
C_8H_{10}	Ethylbenzene	14.5	0.8708	1.49423	1.49828	1.50953	1.51904	(20,† 95, 148)
C_8H_{10}	*o*-Xylene	15.5	0.8837	1.50368	1.50777	1.51960	1.52958	(20,† 105, 148)
C_8H_{10}	*m*-Xylene	14.85	0.8686	1.49548	1.49962	1.51128	1.52112	(20,† 148)
C_8H_{10}	*p*-Xylene	16.2	0.8624	1.49335	1.49734	1.50912	1.51902	(20,† 105, 148)
$C_8H_{10}N_2O_2$	Benzylmethylnitroamine	25.7	1.1706	1.54621	1.55150	1.56531	1.57750	(109)
$C_8H_{10}O$	*o*-Methoxytoluene	15.3	0.9854	1.51447	1.51888	1.53150	1.54238	(16,† 47)
$C_8H_{10}O$	*m*-Methoxytoluene	12.85	0.9784	1.51184	1.51638	1.52892	1.53981	(47)
$C_8H_{10}O$	*p*-Methoxytoluene	19.3	0.9709	1.50797	1.51237	1.52488	1.53557	(47)
$C_8H_{10}O$	Phenetole	13.7	0.9698	1.50605	1.51026	1.52242	1.53273	(47)
$C_8H_{10}OS$	α-Butyrothienone	17.2	1.0912	1.53747	1.54312*	1.55806	1.57136	(59)
$C_8H_{10}OS$	α-Ethyl-α′-acetothienone	16.2	1.0832	1.54576	1.55227*	1.56951	1.58636	(59)
$C_8H_{11}Cl$	1, 3-Dimethyl-5-chloro-3, 5-cyclohexadiene	15.4	1.0065	1.50022	1.50459	1.51626		(77)
$C_8H_{11}ClO$	1, 1-Dimethyl-5-chloro-4-cyclohexen-3-one	19.7	1.0841	1.49175	1.49547	1.50550	1.51434	(67)
$C_8H_{11}Cl_3O_3$	Ethyl γ, γ, γ-trichloro-β-acetylbutyrate	14.1	1.3395	1.46224	1.46458	1.47079	1.47612	(81)
$C_8H_{11}ClO_4$	Diethyl chlorofumarate	18.3	1.1890	1.45455	1.45782	1.46594	1.47299	(80)
$C_8H_{11}N$	Amylpropiolic nitrile	13	0.8508	1.45247	1.4553	1.46333	1.46952	(150)
$C_8H_{11}N$	*vic.*-*o*-Xylidine	15.3	0.9963	1.56493	1.57063	1.58664	1.60058	(47)
$C_8H_{11}N$	*m*-Xylidine	19.6	0.9783	1.55472	1.56066	1.57616	1.59018	(106)
$C_8H_{11}N$	*asym.*-*m*-Xylidine	14.75	0.9786	1.55579	1.56155	1.57748	1.59132	(47)
$C_8H_{11}N$	*sym.*-*m*-Xylidine	12.1	0.9791	1.55622	1.56179	1.57761	1.59140	(47)
$C_8H_{11}N$	*vic.*-*m*-Xylidine	14.05	0.9846	1.55785	1.56347	1.57922	1.59281	(47)
$C_8H_{11}N$	*p*-Xylidine	21.3	0.9790	1.55329	1.55914		1.58803	(106)
$C_8H_{11}N$	Dimethylaniline	20	0.9575	1.55203	1.55873	1.57658	1.59332	(91, 95, 106,† 131)
$C_8H_{11}N$	Ethylaniline	20.3	0.9620	1.54939	1.55558		1.58631	(106)
$C_8H_{11}NO$	1-Methyl-1-cyanocyclohexan-2-one	16.1	1.0189	1.45976	1.46239*	1.46820	1.47341	(39)
$C_8H_{11}NO$	3-Methyl-1-cyanocyclohexan-2-one	15.5	1.0443	1.47084	1.47305*	1.47969	1.48479	(39)
$C_8H_{11}NO$	1-Methyl-2, 3-(α, β-tetrahydrobenz)-isoxazole	16.2	1.0628	1.48956	1.49262*	1.50031	1.50679	(31)
$C_8H_{11}NO$	1-Methyl-2, 3-(β, γ-tetrahydrobenz)-isoxazole	13.0	1.0687	1.49206	1.49517*	1.50287	1.50943	(31)
$C_8H_{11}NO_2$	α-Cyano-Δ^1-isoheptenic acid	99.6	0.9715	1.44367	1.44690	1.45599	1.46409	(58)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_8H_{11}NO_3$	Ethyl α-cyano-Δ^1-pentenate	19.9	1.0004	1.44988	1.45292	1.46152	1.46869	(58)
$C_8H_{11}NO_2$	Ethyl α-propiocyanoacetate	20	1.0762	1.4567	1.4603	1.4697	1.4780	(138)
$C_8H_{11}NO_3$	Methyl α-butyrocyanoacetate	20	1.0933	1.4722	1.4763	1.4871	1.4968	(138)
$C_8H_{11}NO_4$	Diethyl cyanomalonate	20	1.0931	1.4240	1.4263	1.4316	1.4362	(138)
C_8H_{12}	$\Delta^{1,3}$-Dihydro-*p*-xylene	19.5	0.8363	1.47467	1.47888	1.48983	1.49998	(51)
C_8H_{12}	1, 3-Dimethyl-3, 5-cyclohexadiene	19.7	0.8189	1.46828	1.47212	1.48214	1.49096	(77)
C_8H_{12}	1, 4-Dimethyl-1, 3-cyclohexadiene	16.1	0.8370	1.47787	1.48219	1.49380	1.50459	(43, 54†)
C_8H_{12}	1-Methyl-3-methene-1-cyclohexene	17.0	0.8389	1.48274	1.48723	1.49872	1.50910	(44)
$C_8H_{12}ClN$	Dimethylaniline hydrochloride	18.5	1.1156	1.56140	1.56619	1.57829	1.58910	(161)
$C_8H_{12}Cl_2O$	1-Methyl-1-dichloromethylcyclohexan-2-one	17.5	1.2350	1.49798	1.50076	1.50738	1.51332	(67)
$C_8H_{12}Cl_2O$	1-Methyl-1-dichloromethylcyclohexan-4-one	52.8	1.2214	1.49459	1.49775	1.50402	1.50996	(67)
$C_8H_{12}Cl_2O_2$	Suberyl chloride	20.6	1.1720	1.46562	1.46847	1.47485	1.48049	(80)
$C_8H_{12}N_2$	2, 5-Dimethyl-3-ethylpyrazine	24.0	0.9657	1.49683	1.50136		1.52429	(106)
$C_8H_{12}N_2$	*asym.*-Ethylphenylhydrazine	20.8	1.0181	1.56462	1.57108*	1.58745	1.60262	(29)
$C_8H_{12}N_2$	2-Methyltetrahydroindazole	21.5	1.0287	1.51257	1.51619*	1.52520	1.53298	(60)
$C_8H_{12}O$	1, 3-Dimethyl-6-cyclohexen-5-one	11.7	0.9462	1.48246	1.48705	1.49633	1.50518	(43)
$C_8H_{12}O$	1-Isopropylene-2-ketocyclopentane	20	0.9355	1.46359	1.46660	1.47383	1.47994	(90)
$C_8H_{12}O_2$	Amylpropiolic acid	12.6	0.9623	1.46025	1.46335	1.47100	1.47750	(150)
$C_8H_{12}O_2$	Diallylacetic acid	21.6	0.9474	1.44774	1.45084	1.45831	1.46442	(71, 125)
$C_8H_{12}O_2$	Δ^1-Tetrahydro-*m*-toluic acid	69.0	1.0127	1.47283	1.47630*	1.48496		(26)
$C_8H_{12}O_2$	1-Hydroxymethylene-3-methylcyclohexan-2-one	15.8	1.0540	1.50072	1.50569	1.52010	1.53435	(56)
$C_8H_{12}O_2$	Ethyl sorbate	20.15	0.9560	1.49554	1.50227	1.52001	1.53664	(27, 45†)
$C_8H_{12}O_3$	Acetoxymethylenediethyl ketone	18.25	1.0342	1.46116	1.46486	1.47488	1.48438(?)	(17)
$C_8H_{12}O_3$	Ethyl ethylideneacetoacetate	18	1.0231	1.44945	1.45283	1.46109	1.46882	(45,† 105)
$C_8H_{12}O_4$	Diethyl fumarate	20	1.05199	1.43780	1.44103	1.44902	1.45591	(45,† 144)
$C_8H_{12}O_4$	Diethyl maleate	20	1.06917	1.43779	1.44070	1.44763	1.45352	(45,† 144)
$C_8H_{12}O_4$	Ethyl acetoxymethylenepropionate	18.6	1.0686	1.44558	1.44903	1.45760	1.46501	(17)
$C_8H_{12}O_4$	Ethyl *O*-acetylacetoacetate	14.95	1.0644	1.44402	1.44695	1.45511	1.46179	(17)
$C_8H_{12}O_4$	Ethyl diacetoacetate	18.3	1.0947	1.46512	1.46950	1.48067	1.49125	(17)
$C_8H_{12}O_5$	Diethyl hydroxymethylenemalonate	14.25	1.1275	1.45287	1.45605	1.46502	1.47275	(17)
$C_8H_{12}O_5$	Diethyl oxalacetate	16.6	1.1715	1.45309	1.45614		1.46993	(105)
$C_8H_{13}N$	Tropidine	18.4	0.9535	1.48752	1.49037	1.49793	1.50417	(25)
$C_8H_{13}NO$	Tropinone	99.6	0.9872	1.45975	1.46205	1.46910		(25)
$C_8H_{13}NO_2$	2-Cyano-*n*-heptoic acid	17.0	1.0250	1.44686	1.44940*	1.45495	1.45968	(39)
$C_8H_{13}NO_2$	α-Mesityl oxide oxime acetate	14	0.9925	1.47379	1.47707*	1.48671	1.49522	(74)
$C_8H_{13}NO_2$	β-Mesityl oxide oxime acetate	17.1	0.9922	1.47554	1.47972*	1.48998	1.49852	(74)
C_8H_{14}	1, 1-Dimethyl-3-cyclohexene	16.2	0.8056	1.44251	1.44521	1.45182	1.45722	(68)
C_8H_{14}	1, 2-Dimethyl-1-cyclohexene	13.5	0.8317	1.45906	1.46178	1.46908	1.47517	(55)
C_8H_{14}	1, 3-Dimethyl-3-cyclohexene	22.4	0.8000	1.44263	1.44533	1.45215	1.45795	(55)
C_8H_{14}	1, 3-Dimethyl-4-cyclohexene	18.0	0.8102	1.45014	1.45372	1.46078	1.46728	(77)
C_8H_{14}	1, 3-Dimethyl-5-cyclohexene	21.1	0.797	1.44086	1.44361	1.45020	1.45587	(55)
C_8H_{14}	1, 4-Dimethyl-1-cyclohexene	22	0.7989	1.44112	1.44372	1.45056	1.45626	(55)
C_8H_{14}	Ethenecyclohexane	17.6	0.8237	1.46094	1.46389	1.47139	1.47773	(55)
C_8H_{14}	1-Ethyl-1-cyclohexene	19.05	0.8238	1.45386	1.45673	1.46347	1.46944	(46)
C_8H_{14}	Ethylidenecyclohexane	17.3	0.8244	1.45965	1.46299	1.47010	1.47633	(46)
C_8H_{14}	1-Octine	12.5	0.7530	1.4183	1.42075	1.4272	1.4309	(150)
$C_8H_{14}Cl_2$	1-Methyl-1-dichloromethylcyclohexane	23.7	1.1272	1.48670	1.48947	1.49596	1.50145	(68)
$C_8H_{14}O$	Diallylmethyl carbinol	20.6	0.8437	1.43903	1.44172	1.44856	1.45414	(141)
$C_8H_{14}O$	1, 3-Dimethyl-1-cyclohexen-3-ol	17.5	0.9327	1.47417	1.47711	1.48458	1.49076	(10)
$C_8H_{14}O$	1, 1-Dimethylcyclohexan-2-one	19.9	0.9146	1.44624	1.44863	1.45443	1.45940	(67)
$C_8H_{14}O$	1, 1-Dimethylcyclohexan-3-one	18.6	0.9068	1.44513	1.44763	1.45352	1.45851	(67)
$C_8H_{14}O$	1, 1-Dimethylcyclohexan-4-one	22.45	0.9280	1.45096	1.45334	1.45941	1.46442	(67)
$C_8H_{14}O$	1, 2-Dimethylcyclohexan-4-one	12.6	0.9121	1.44871	1.45094	1.45712	1.46208	(21)
$C_8H_{14}O$	1, 3-Dimethylcyclohexan-2-one	11.85	0.9204	1.44976	1.45189	1.45811	1.46252	(62)
$C_8H_{14}O$	1, 3-Dimethylcyclohexan-5-one	18.2	0.8933	1.44077	1.44333	1.44916	1.45416	(55)
$C_8H_{14}O_2$	Cyclohexylacetic acid	33.5	1.0012	1.45482		1.46303	1.46780	(130)
$C_8H_{14}O_2$	2, 6-Dimethyl-Δ^2-hexenic acid	15.8	0.9360	1.44524	1.44800	1.45514	1.46105	(53)
$C_8H_{14}O_2$	α-Ethyl-Δ^2-hexenic acid	16.5	0.9313	1.44122	1.44364	1.45064	1.45622	(53)
$C_8H_{14}O_2$	Dimethylacetonylacetone	23.0	0.9336	1.42942	1.43168	1.43758	1.44254	(54)
$C_8H_{14}O_2$	Ethoxymethylene diethyl ketone	18.15	0.9446	1.46760	1.47169	1.48289	1.49325(?)	(17)
$C_8H_{14}O_2$	Propylacetylacetone	18.2	0.9363	1.43942	1.44369	1.45106	1.45831	(56)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_8H_{14}O_2$	Ethyl α-ethylcrotonate	17.0	0.9106	1.43407	1.43705*	1.44438	1.45069	(69)
$C_8H_{14}O_2$	Ethyl α, β-hexenate	20	0.9005	1.43165	1.43474*	1.44200	1.44849	(69)
$C_8H_{14}O_2$	Ethyl α, β-isohexenate	18.5	0.8971	1.43043	1.43363*	1.44079	1.44704	(69)
$C_8H_{14}O_2$	Ethyl trimethylacrylate	19.3	0.9072	1.42680	1.42987	1.43718	1.44360	(43,† 69)
$C_8H_{14}O_3$	Ethyl cyclopentan-1-ol-1-carboxylate	16.0	1.0604	1.44897	1.45160	1.45693	1.46171	(63)
$C_8H_{14}O_3$	Ethyl dimethylacetoacetate	18.8	0.9771	1.41616	1.41828	1.42358	1.42819	(9)
$C_8H_{14}O_3$	Ethyl ethylacetoacetate	16.1	0.9835	1.42147	1.42366	1.42936	1.43434	(9,† 105)
$C_8H_{14}O_3$	Ethyl β-ethoxycrotonate	37.6	0.9663	1.44307	1.44678	1.45571	1.46324	(6)
$C_8H_{14}O_3$	Ethyl β-ethoxy-α-methylacrylate	21.6	0.9788	1.44649	1.45009	1.45931	1.46760	(5)
$C_8H_{14}O_4$	Diethyl methylmalonate	18.7	1.0192	1.41154	1.41369	1.41881	1.42310	(9)
$C_8H_{14}O_4$	Diethyl succinate	15.5	1.0454	1.42013	1.42227*	1.42738	1.43160	(73,† 105)
$C_8H_{14}O_4$	Diethyl methylpyrotartrate	21.9	1.0285	1.41748	1.41959		1.42897	(102)
$C_8H_{15}Br$	1, 3-Dimethylcyclohexyl bromide	18.2	1.2074	1.48020	1.48321	1.49033	1.49626	(55)
$C_8H_{15}Cl$	1, 2-Dimethylcyclohexyl chloride	13.3	0.9708	1.46492	1.46723	1.47407		(21)
$C_8H_{15}Cl$	1, 4-Dimethylcyclohexyl chloride	18.5	0.9438	1.45088	1.45372	1.45942	1.46462	(21)
$C_8H_{15}N$	γ-Coniceine	18.4	0.8740	1.45808	1.46068	1.46707	1.47251	(109)
$C_8H_{15}N$	Tropane	21.6	0.9307	1.47427	1.47659	1.48318	1.48854	(25)
$C_8H_{15}NO$	Tropine	99.8	1.0161	1.47917	1.48113	1.48766	1.49269	(25)
C_8H_{16}	1, 2-Dimethylcyclohexane	17.85	0.7809	1.42820	1.43020	1.43592	1.44056	(21,† 130)
C_8H_{16}	1, 3-Dimethylcyclohexane	20.75	0.7707	1.42276	1.42499	1.43047	1.43500	(55)
C_8H_{16}	1, 4-Dimethylcyclohexane	15.7	0.7722	1.42407	1.42597	1.43174	1.43624	(21,† 130)
C_8H_{16}	Octylene	16.0	0.7256	1.4137	1.4157	1.4222	1.4274	(95, 148†)
$C_8H_{16}N_2$	Ethylmethylketazine	26.6	0.8338	1.44826	1.45160	1.46000	1.46717	(109)
$C_8H_{16}O$	Allyldiethyl carbinol	21.7	0.8470	1.43853	1.44100	1.44723	1.45235	(141)
$C_8H_{16}O$	Allylmethylpropyl carbinol	21.3	0.8340	1.43501	1.43758	1.44385	1.44889	(141)
$C_8H_{16}O$	1, 1-Dimethylcyclohexan-2-ol	22.4	0.9257	1.46404	1.46640	1.47240	1.47735	(67)
$C_8H_{16}O$	1, 1-Dimethylcyclohexan-3-ol	19.7	0.9089	1.45655	1.45893	1.46476	1.46964	(67)
$C_8H_{16}O$	1, 1-Dimethylcyclohexan-4-ol	24.7	0.9220	1.45896	1.46128	1.46716	1.47214	(67,† 68)
$C_8H_{16}O$	1, 2-Dimethylcyclohexan-2-ol	13.7	0.9252	1.46035	1.46248	1.46848	1.47330	(21)
$C_8H_{16}O$	1, 2-Dimethylcyclohexan-4-ol	12.5	0.9118	1.45826	1.46042	1.46645	1.47121	(21)
$C_8H_{16}O$	1, 3-Dimethylcyclohexan-3-ol	22.9	0.9028	1.45177	1.45414	1.45984	1.46463	(55)
$C_8H_{16}O$	1, 3-Dimethylcyclohexan-5-ol	18.55	0.8996	1.45354	1.45601	1.46181	1.46652	(55)
$C_8H_{16}O$	1, 4-Dimethylcyclohexan-4-ol	23.9	0.9060	1.45317	1.45534	1.46141	1.46622	(55)
$C_8H_{16}O$	Methylhexyl ketone	20	0.8185	1.41390	1.41613	1.42133	1.42569	(93)
$C_8H_{16}O_2$	*cis*-Tetramethylbutenediol	98.9	0.8693	1.42026	1.42258*	1.42884		(73)
$C_8H_{16}O_2$	*trans*-Tetramethylbutenediol	99.2	0.8634	1.41875	1.42164*	1.42747		(73)
$C_8H_{16}O_2$	Octoic acid	21	0.90866	1.42439	1.42677	1.43194	1.43654	(125)
$C_8H_{17}N$	Coniine	21.9	0.8430	1.44867	1.45119		1.46239	(106,† 157)
$C_8H_{17}N$	*sym.*-Copellidine	19.0	0.8315	1.44113	1.44354	1.44982	1.45524	(25)
$C_8H_{17}NO$	Oenanthaldoxime methyl ether	19.4	0.8384	1.42192	1.42431		1.43578	(106)
$C_8H_{17}NO$	Isocaproimido ethyl ether	17.9	0.8575	1.41766	1.41996	1.42526	1.42957	(109)
$C_8H_{17}NO$	Methyl hexylketoxime	20.8	0.8845	1.44899	1.45166		1.46339	(106)
C_8H_{18}	Octane	17.6	0.7046	1.39677	1.39883	1.40372	1.40781	(129, 148)
$C_8H_{18}N_2O$	Nitrosodiisobutylamine	21.2	0.8915	1.44094	1.44387	1.45147	1.45810	(106)
$C_8H_{18}O$	Octyl alcohol	9.5		1.4246	1.4279	1.4338	1.4386	(134)
$C_8H_{18}O$	Methylhexyl carbinol	20	0.8193	1.42231	1.42444	1.42972	1.43397	(93)
$C_8H_{19}N$	Diisobutylamine	19.6	0.7450	1.40712	1.40934		1.41919	(106)
C_9H_5N	Phenylpropiolic nitrile	41.5	1.0046	1.5775	1.58535	1.6068	1.62066	(150)
C_9H_6ClN	α-Chloroquinoline	24.6	1.2464	1.62586	1.63417	1.65650	1.67721	(106)
C_9H_6O	Phenylpropiolic aldehyde	12.6	1.0680	1.59745	1.60785	1.63214	1.64930	(150)
C_9H_7BrO	1-Methyl-4-bromocoumarone	34.8	1.4771	1.58473	1.59149	1.60979	1.62638	(23)
C_9H_7ClO	Cinnamyl chloride	42.5	1.1645	1.60451	1.61364	1.64950	1.68531	(80)
C_9H_7N	Quinoline	24.9	1.0895	1.61610	1.62450	1.64702	1.66790	(106,† 134, 145)
C_9H_7N	Isoquinoline	25.1	1.0974	1.61411	1.62233	1.64430	1.66476	(106,† 109, 157)
C_9H_8	Indene	12.7	1.01995	1.56454	1.57107	1.58743	1.60220	(161)
$C_9H_8Cl_4$	3, 5-Dichloro-1-methyl-4-(β, β-dichloroethyl)-benzene	19.0	1.3976	1.56306	1.56784	1.57991	1.59033	(4)
$C_9H_8Cl_4$	3, 5-Dichloro-1-methyl-1-dichloromethyl-4-methene-2, 5-cyclohexadiene	16.7	1.4084	1.57462	1.58005	1.59387		(4)
$C_9H_8N_2$	1-Phenylpyrazole	14.6	1.1177	1.59160	1.59890*	1.61747	1.63470	(60)
$C_9H_8N_2$	Toluquinoxaline	18.4	1.1180	1.61205	1.62112	1.64639	1.67196	(109)
$C_9H_8N_2O$	2-Acetylindazole (stable)	16.8	1.1886	1.58240	1.58955*	1.60812	1.62611	(33)
C_9H_8O	Cinnamaldehyde	20	1.0497	1.60852	1.61949	1.65090	1.68295	(45,† 95)
C_9H_8O	1-Methylcoumarone	14.4	1.0588	1.55479	1.56145	1.57783	1.59297	(23)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
C_9H_8O	2-Methylcoumarone	23.1	1.0543	1.54663	1.55255	1.56824	1.58224	(41)
C_9H_8O	4-Methylcoumarone	19	1.0605	1.55117	1.55729	1.57300	1.58743	(41)
C_9H_8O	α-Hydrindone	44.75	1.0938	1.55500	1.56084	1.57655	1.59206	(16)
C_9H_8OS	2-Methoxythionaphthene	13.6	1.2093	1.61990	1.62767	1.64810		(41)
$C_9H_8O_2$	2-Methoxycoumarone	19.3	1.1443	1.55277	1.55894	1.57489	1.58941	(41)
$C_9H_8O_2$	Methylphthalide	22	1.1559	1.53918	1.54380	1.55703	1.56828	(145)
$C_9H_8O_2$	1-Methylcoumaranone	19.7	1.1531	1.55620	1.56321	1.58288	1.60277	(19)
$C_9H_8O_2$	4-Methylcoumaranone	53.8	1.1506	1.55808	1.56521	1.58638		(19)
$C_9H_8O_3$	*o*-Acetoxybenzaldehyde	44.5	1.1580	1.51715	1.52254	1.53646	1.54940	(41)
$C_9H_8O_3$	α-Methoxyphthalide	22.8	1.2151	1.53089	1.53522	1.54758	1.55815	(49)
$C_9H_8O_3$	Methyl *o*-phthalaldehydecarboxylate	19.6	1.2027	1.53635	1.54143	1.55596	1.56898	(49)
C_9H_8S	4-Methylthionaphthene	21.65	1.1108	1.60730	1.61476	1.63374	1.65141	(41)
C_9H_9BrO	α-Bromopropiophenone	19.6	1.4302	1.56617	1.57175	1.58770	1.60204	(15)
C_9H_9BrO	1-Methyl-4-bromocoumarane	14.4	1.4581	1.56684	1.57270	1.58670	1.59943	(16)
$C_9H_9BrO_2$	Ethyl *o*-bromobenzoate	15.4	1.4438	1.54088	1.54548	1.55837	1.56941	(47)
$C_9H_9BrO_2$	Ethyl *m*-bromobenzoate	18.9	1.4308	1.53836	1.54298	1.55616	1.56729	(47)
$C_9H_9BrO_2$	Ethyl *p*-bromobenzoate	17.3	1.4332	1.54329	1.54829	1.56261	1.57505	(47)
$C_9H_9ClO_2$	Ethyl *o*-chlorobenzoate	15.4	1.1942	1.52044	1.52470	1.53686	1.54717	(47)
$C_9H_9ClO_2$	Ethyl *m*-chlorobenzoate	15.4	1.1859	1.51803	1.52233	1.53454	1.54500	(47)
$C_9H_9ClO_2$	Ethyl *p*-chlorobenzoate	14.0	1.1873	1.52246	1.52700	1.54013	1.55150	(47)
$C_9H_9Cl_3$	5-Chloro-1-methyl-4-(β, β-dichloroethyl)-benzene	20.3	1.2874	1.54258	1.55012	1.56130	1.57143	(4)
C_9H_9NO	μ-Phenyloxazoline	23.4	1.1223	1.55975	1.56554	1.58074	1.59429	(106)
C_9H_{10}	Hydrindene	16.4	0.96250	1.53394	1.53877	1.55114	1.56136	(161)
C_9H_{10}	*o*-Methylstyrene	14.1	0.9155	1.54175	1.54765	1.56444	1.57904	(14)
C_9H_{10}	*p*-Methylstyrene	16.4	0.9003	1.53811	1.54465	1.56200	1.57784	(8)
C_9H_{10}	α-Methylstyrene	19.8	0.9078	1.52893	1.53492	1.54959	1.56284	(43)
C_9H_{10}	β-Methylstyrene	18.7	0.9145	1.54257	1.54967	1.56600	1.58103	(43)
$C_9H_{10}Cl_2O$	1, 3-Dimethyl-1-dichloromethyl-2, 5-cyclohexadien-4-one	20.5	1.2405	1.53960	1.54379	1.55613	1.56675	(89)
$C_9H_{10}Cl_2O$	1, 5-Dimethyl-1-dichloromethyl-3, 5-cyclohexadien-2-one	19.8	1.2250	1.52906	1.53366	1.54766		(88)
$C_9H_{10}N_2$	1-Ethylindazole	14.7	1.0678	1.56918	1.57577*	1.59267	1.60856	(60)
$C_9H_{10}N_2$	2-Ethylindazole	16.2	1.0768	1.58564	1.59310*	1.61238	1.63081	(60)
$C_9H_{10}O$	*o*-Allylphenol	14.25	1.0262	1.54290	1.54853	1.56164	1.57345	(47)
$C_9H_{10}O$	Cinnamyl alcohol	20	1.0440	1.57510	1.58190	1.59993	1.61631	(43,† 95, 132, 155, 156)
$C_9H_{10}O$	*o*-Propenylphenol	14.25	1.0438	1.57670	1.58368	1.60310	1.62110	(14)
$C_9H_{10}O$	Ethyl phenyl ketone	15.9	1.0134	1.52375	1.52900	1.54223	1.55403	(8)
$C_9H_{10}O$	*o*-Methylacetophenone	12.75	1.0203	1.52963	1.53522	1.54885	1.56134	(41)
$C_9H_{10}O$	*m*-Methylacetophenone	15.3	1.0108	1.52697	1.53270	1.54654	1.55946	(41)
$C_9H_{10}O$	*p*-Methylacetophenone	17.4	1.0061	1.52976	1.53533	1.55018	1.56369	(8)
$C_9H_{10}O$	*o*-Methoxystyrene	17.4	1.0047	1.55016	1.55701	1.57526	1.59233	(14)
$C_9H_{10}O$	α-Methoxystyrene	25.0	0.9936	1.53402	1.53997	1.55521	1.56918	(5)
$C_9H_{10}O$	β-Methoxystyrene	24.3	0.9886	1.55467	1.56197	1.58139	1.59962	(5)
$C_9H_{10}O$	1′-Methyl-2-hydroxystyrene	18.5	1.0296	1.54328	1.54904	1.56368	1.57699	(14)
$C_9H_{10}O$	1′-Methyl-3-hydroxystyrene	13.0	1.0476	1.56721	1.57337	1.59064	1.60612	(14)
$C_9H_{10}O$	Chavicol	18	1.033	1.5393	1.5441	1.5573	1.6689	(128)
$C_9H_{10}O$	Chromane	14.1	1.0697	1.54601	1.55063	1.56376	1.57526	(16)
$C_9H_{10}O$	1-Methylcoumarane	13.7	1.0363	1.52919	1.53375	1.54678	1.55800	(16)
$C_9H_{10}O$	4-Methylcoumarane	18.6	1.0463	1.53521	1.54044	1.55351	1.56537	(16)
$C_9H_{10}O_2$	*o*-Methoxy-*m*-toluic aldehyde	19.2	1.0988	1.54672	1.55375	1.57328		(41)
$C_9H_{10}O_2$	2-Hydroxy-5-methylacetophenone	53	1.0797	1.53426	1.54095	1.56135		(41)
$C_9H_{10}O_2$	α-Hydroxypropiophenone	22.8	1.1044	1.53104	1.53558	1.54873		(15)
$C_9H_{10}O_2$	*o*-Methoxyacetophenone	23.6	1.0850	1.53214	1.53787	1.55339	1.56792	(41)
$C_9H_{10}O_2$	*m*-Methoxyacetophenone	15.35	1.0993	1.53693	1.54313	1.55829	1.57247	(41)
$C_9H_{10}O_2$	*p*-Methoxyacetophenone	41.3	1.0816	1.53998	1.54684	1.56443	1.58094	(41)
$C_9H_{10}O_2$	*o*-Ethylbenzoic acid	99.6	1.0420	1.50559	1.51012	1.52333	1.53455	(145)
$C_9H_{10}O_2$	Ethyl benzoate	17.3	1.0496	1.50179	1.50682	1.51839	1.52854	(43)
$C_9H_{10}O_3$	Ethyl salicylate	14.4	1.1355	1.51977	1.52511	1.54036	1.55466	(41)
$C_9H_{10}O_3$	Methyl *o*-methoxybenzoate	19.5	1.1566	1.52893	1.53422	1.54789	1.56029	(41)
$C_9H_{11}BrO$	2-Ethoxy-4-bromotoluene	11.35	1.3592	1.54387	1.54858	1.56186	1.57332	(16)
$C_9H_{11}I$	*sym.*-Iodopseudocumene	65.3	1.5113	1.57573	1.58129	1.59673		(47)
$C_9H_{11}N$	2-Dihydromethylindole	23.4	1.0197	1.56264	1.56868		1.59979	(106)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_9H_{11}N$	Tetrahydroisoquinoline	23.1	1.0642	1.57418	1.57982		1.60681	(106)
$C_9H_{11}N$	Tetrahydroquinoline	23.9	1.0546	1.58675	1.59331	1.61093	1.62721	(106)
$C_9H_{11}NO$	α-Benzaldoxime ethyl ether	21.7	0.9918	1.52880	1.53498	1.55126	1.56628	(106)
$C_9H_{11}NO_2$	*o*-Anisaldoxime methyl ether	18.6	1.0934	1.54784	1.55505*	1.57405	1.59287	(31)
C_9H_{12}	1, 1-Dimethyl-4-methene-2, 5-cyclohexadiene	15.8	0.8360	1.49799	1.50295	1.51739	1.53009	(89)
C_9H_{12}	Isopropylbenzene	16.8	0.8662	1.49063	1.49441	1.50539	1.51466	(20,† 148)
C_9H_{12}	Mesitylene	17.1	0.8646	1.49403	1.49804	1.50936	1.51891	(20,† 75, 92, 148)
C_9H_{12}	*o*-Methylethylbenzene	16.05	0.8831	1.50148	1.50569	1.51697	1.52653	(16, 20†)
C_9H_{12}	*m*-Methylethylbenzene	19.9	0.8669	1.49575	1.49966	1.51102	1.52056	(20, 61†)
C_9H_{12}	*p*-Methylethylbenzene	22.8	0.8597	1.48921	1.49303	1.50417	1.51353	(20,† 61, 145)
C_9H_{12}	Propylbenzene	12.25	0.8681	1.49176	1.49549	1.50630	1.51533	(20,† 148)
C_9H_{12}	Pseudocumene	15.3	0.8794	1.50259	1.50672	1.51841	1.52816	(20,† 105, 148)
C_9H_{12}	1, 2, 3-Trimethylbenzene	19.55	0.8949	1.50930	1.51335	1.52503	1.53483	(20)
$C_9H_{12}Cl_2O$	1, 4-Dimethyl-4-dichloromethyl-1-cyclohexen-3-one	45.8	1.2067	1.51125	1.51508	1.52494	1.53365	(52)
$C_9H_{12}N_2O$	2-Acetyltetrahydroindazole	24.0	1.1148	1.52635	1.53098*	1.54227	1.55266	(60)
$C_9H_{12}O$	*o*-Ethoxytoluene	13.3	0.9592	1.50383	1.50791	1.51974	1.52987	(16, 47)
$C_9H_{12}O$	*m*-Ethoxytoluene	11.7	0.9558	1.50507	1.50920	1.52112	1.53112	(47)
$C_9H_{12}O$	*p*-Ethoxytoluene	17.6	0.9509	1.50175	1.50582	1.51749	1.52793	(47)
$C_9H_{12}O$	*asym.*-Methoxy-*m*-xylene	12.85	0.9696	1.51298	1.51730	1.52967	1.54023	(16)
$C_9H_{12}O$	Benzylmethyl carbinol	14.5	0.9988	1.52017	1.52425	1.53453	1.54355	(57)
$C_9H_{12}O$	Phenylpropyl alcohol	20	1.0079	1.53101	1.53565	1.54782	1.55829	(92)
$C_9H_{12}O$	*m*-Tolylmethyl carbinol	15.35	0.9973	1.52262	1.52635	1.53740	1.54710	(41)
$C_9H_{12}O$	*p*-Tolylmethyl carbinol	18.4	1.0045	1.52880	1.53391	1.54835	1.56127	(61)
$C_9H_{12}O$	*asym.*-*o*-Xylenyl methyl ether	13.7	0.9744	1.51545	1.51980	1.53194	1.54249	(47)
$C_9H_{12}O$	*vic.*-*o*-Xylenyl methyl ether	39.7	0.9596	1.50786	1.51197	1.52418	1.53434	(47)
$C_9H_{12}O$	*asym.*-*m*-Xylenyl methyl ether	12.85	0.9696	1.51298	1.51730	1.52967	1.54023	(16,† 47)
$C_9H_{12}O$	*sym.*-*m*-Xylenyl methyl ether	15.1	0.9627	1.51056	1.51485	1.52695	1.53730	(47)
$C_9H_{12}O$	*vic.*-*m*-Xylenyl methyl ether	13.6	0.9619	1.50148	1.50533	1.51666	1.52610	(47)
$C_9H_{12}O$	*p*-Xylenyl methyl ether	12.8	0.9693	1.51388	1.51818	1.53057	1.54106	(47)
$C_9H_{12}OS$	α-Isovalerothienone	14.4	1.0677	1.53246	1.53803*	1.55238	1.56627	(59)
$C_9H_{12}OS$	α-Propyl-α′-acetothienone	14.6	1.0663	1.54079	1.54710*	1.56368	1.57997	(59)
$C_9H_{12}O_2$	*o*-Hydroxydihydrocinnamyl alcohol	15.0	1.1259	1.55121	1.55576	1.56805	1.57881	(16)
$C_9H_{12}O_2$	1, 4-Dimethyl-1, 3-cyclohexadien-3-carboxylic acid	18.5	1.0446	1.49024	1.49384	1.50331	1.51158	(54)
$C_9H_{12}O_3$	Acetoxymethylenecyclohexanone	15.6	1.1152	1.49537	1.49936	1.51041		(17)
$C_9H_{12}O_4$	Dimethyl isoprenedicarboxylate	42.7	1.0964	1.49870	1.50482*	1.52115	1.53691	(27)
$C_9H_{13}BrO_5$	Diethyl α-bromoacetylmalonate	18.1	1.3905	1.45777	1.46024	1.46712	1.47283	(34)
$C_9H_{13}ClO_5$	Diethyl α-chloroacetylmalonate	12.25	1.1948	1.44243	1.44456	1.45073	1.45573	(34)
$C_9H_{13}Cl_3O$	1, 1, 1-Trichloro-2-hydroxy-3-nonine	9.9	1.2342	1.49695	1.5000	1.50735	1.51216	(150)
$C_9H_{13}N$	Dimethyl-*o*-toluidine	23.3	0.9250	1.51932	1.52437		1.54841	(106)
$C_9H_{13}N$	Dimethyl-*p*-toluidine	20.2	0.9366	1.54061	1.54686		1.57784	(106)
$C_9H_{13}N$	Hexylpropiolic nitrile	14.4	0.8493	1.45344	1.45637	1.46410	1.46977	(150)
$C_9H_{13}NO$	1-Ethyl-1-cyanocyclohexan-2-one	13.6	1.0136	1.46619	1.46851	1.47476	1.47980	(39)
$C_9H_{13}NO$	1-Cyano-2-ethoxy-1-cyclohexene	13.9	1.0243	1.49320	1.49657	1.50627		(39)
$C_9H_{13}NO_3$	Ethyl α-butyro-α-cyanoacetate	20	1.0561	1.4577	1.4614	1.4706	1.4789	(138)
$C_9H_{13}NO_3$	Ethyl α-isobutyro-α-cyanoacetate	20	1.0542	1.4570	1.4606	1.4699	1.4782	(138)
$C_9H_{13}NO_4$	Diethyl methylcyanomalonate	20	1.0695	1.4209	1.4232	1.4282	1.4324	(138)
C_9H_{14}	1-Methyl-4-ethyl-1, 3-cyclohexadiene	19.4	0.8371	1.47828	1.48250	1.49353	1.50422	(43, 52†)
$C_9H_{14}Cl_2$	1, 4-Dimethyl-1-dichloromethyl-3-cyclohexene	23	1.1227	1.49622	1.49913	1.50650	1.51275	(68)
$C_9H_{14}N_2$	2, 7-Dimethyltetrahydroindazole	19.1	1.0126	1.50872	1.51233*	1.52099	1.52848	(60)
$C_9H_{14}O$	*asym.*-Diallylacetone	20.9	0.8591	1.44322	1.44622	1.45363	1.45991	(71)
$C_9H_{14}O$	*sym.*-Diallylacetone	14.0	0.8684	1.44752	1.45041	1.45789	1.46418	(71,† 125)
$C_9H_{14}O$	Phorone	20	0.8850	1.49393	1.49982	1.51527		(95)
$C_9H_{14}O$	α, β-Pulenenone	16.5	0.9317	1.47613	1.47958	1.48884	1.49688	(43,† 50)
$C_9H_{14}O$	β, γ-Pulenenone	17.7	0.9055	1.45305	1.45582	1.46277	1.46866	(50)
$C_9H_{14}O$	1, 1, 3-Trimethyl-2-cyclohexen-4-one	16.3	0.9332	1.47622	1.47951	1.48857	1.49645	(21)
$C_9H_{14}O_2$	α-Cyclohexenepropionic acid	20.3	1.0099	1.47240	1.47526	1.48253	1.48871	(46)
$C_9H_{14}O_2$	Hexylpropiolic acid	12.5	0.9525	1.4611	1.46429	1.4715	1.4777	(150)
$C_9H_{14}O_2$	2-Methylcyclohexeneacetic acid	15.8	1.0277	1.47896	1.48170			(46)
$C_9H_{14}O_2$	3-Methylcyclohexeneacetic acid	15.4	1.0273	1.47935	1.48239	1.48953	1.49515	(46)

Formula	Name	*t*, °C	d_4^t	α	D	β	γ	Lit.
$C_9H_{14}O_2$	1-Hydroxymethylene-4, 5-dimethylcyclohexan-2-one	15.9	1.0257	1.49489	1.49950	1.51278	1.52562	(56)
$C_9H_{14}O_2$	Ethoxymethylenecyclohexanone	10.8	1.0291	1.49615	1.50019	1.51161	1.52218	(17)
$C_9H_{14}O_2$	Ethyl *α*-methylsorbate	16.5	0.9501	1.49306	1.49907*	1.51492	1.52998	(27)
$C_9H_{14}O_2$	Ethyl *γ*-methylsorbate	15.6	0.9499	1.49484	1.50087*	1.51642	1.53138	(27)
$C_9H_{14}O_2$	Ethyl Δ^1-tetrahydrobenzoate	14.15	1.0032	1.46793	1.47167*	1.47885	1.48558	(26)
$C_9H_{14}O_2$	Methyl amylpropiolate	12.3	0.9335	1.4477	1.45092	1.4579	1.4635	(150)
$C_9H_{14}O_2$	Methyl cyclohexeneacetate	18.2	1.0032	1.46561	1.46871	1.47558	1.48165	(46)
$C_9H_{14}O_2$	Methyl cyclohexylideneacetate	19.7	0.9989	1.47916	1.48308	1.49187	1.49959	(46)
$C_9H_{14}O_3$	Acetoxymethylenemethyl-*tert.*-butyl ketone	53.3	0.9645	1.44122	1.44434	1.45359	1.46226(?)	(17)
$C_9H_{14}O_3$	Ethyl allylacetoacetate	17.6	0.9922	1.43602	1.43875		1.45031	(105)
$C_9H_{14}O_3$	Ethyl isopropylideneacetoacetate	19.9		1.44915	1.45233	1.46024	1.46729	(45)
$C_9H_{14}O_4$	Diethyl citraconate	20	1.0624	1.44380	1.44693	1.45439	1.46098	(45,† 144)
$C_9H_{14}O_4$	Diethyl itaconate	20	1.0461	1.43614	1.43884	1.44532	1.45082	(44, 144)
$C_9H_{14}O_4$	Diethyl mesaconate	20	1.04674	1.44599	1.44931	1.45751	1.46460	(45,† 144)
$C_9H_{14}O_4$	Diethyl ethylidenemalonate	16.1	1.0426	1.43798	1.44084	1.44785	1.45393	(45)
$C_9H_{14}O_4$	Ethyl ethoxymethyleneacetoacetate	16.9	1.0709	1.47210	1.47623	1.48710	1.49708	(17)
$C_9H_{14}O_4$	Ethyl acetoneoxalate *O*-ethyl ether	15.3	1.0644	1.46655	1.47103	1.48316	1.49452	(42)
$C_9H_{14}O_5$	Diethyl acetonedicarboxylate	23.6	1.1071	1.43529	1.43775		1.44936	(105)
$C_9H_{14}O_5$	Diethyl acetylmalonate	14.2	1.1051	1.44574	1.44860	1.45692	1.46411	(56,† 105)
$C_9H_{14}O_5$	Ethyl *β*-hydroxycarbethoxy-*α*, *β*-crotonate	23.9	1.0890	1.43808	1.44097	1.44809	1.45414	(43,† 105)
$C_9H_{14}S$	*α*-Isoamylthiophene	11.8	0.9481	1.49750	1.50144*	1.51096	1.51930	(59)
$C_9H_{15}ClO$	*α*, *β*-Nonylenyl chloride	19.2	0.9675	1.45738	1.46075*	1.46876	1.47608	(69)
$C_9H_{15}N$	*α*, *β*-Nonylenic nitrile	15.1	0.8365	1.44454	1.44758*	1.45483	1.46096	(69)
$C_9H_{15}NO$	Pseudopelletierine	99.5	1.0014	1.47351	1.47596	1.48289	1.48861	(25)
C_9H_{16}	1, 3-Dimethyl-5-methenecyclohexane	14.6	0.7918	1.44334	1.44628	1.45313	1.45917	(55)
C_9H_{16}	1-Isopropyl-1-cyclohexene	15.2	0.8320	1.45884	1.46150	1.46851	1.47436	(46)
C_9H_{16}	Isopropylidenecyclohexane	15.8	0.8398	1.47181	1.47466	1.48203	1.48869	(46)
C_9H_{16}	Geraniolene	21.5	0.7680	1.44222	1.44532	1.45324	1.45912	(71)
C_9H_{16}	1, 1, 2-Trimethyl-2-cyclohexene	20.4	0.8216	1.45336	1.45603	1.46298	1.46877	(68)
C_9H_{16}	1, 1, 4-Trimethyl-3-cyclohexene	23.15	0.8021	1.44152	1.44422	1.45086	1.45652	(68)
C_9H_{16}	1, 2, 3-Trimethyl-1-cyclohexene	11.75	0.8347	1.46015	1.46296	1.47021	1.47603	(62)
C_9H_{16}	1, 2, 5-Trimethyl-4-cyclohexene	16.15	0.8078	1.44742	1.44990	1.45683	1.46264	(21)
C_9H_{16}	1, 3, 5-Trimethylcyclohexene	24.7	0.7941	1.44102	1.44378	1.45057	1.45638	(55)
$C_9H_{16}Br_2$	1, 1, 4-Trimethyl-3, 4-dibromocyclohexane	18.7	1.5320	1.52474	1.52805	1.53642	1.54354	(68)
$C_9H_{16}O$	1, 1, 3-Trimethylcyclohexan-4-one	16.45	0.9045	1.44907	1.45130	1.45732	1.46240	(21)
$C_9H_{16}O$	1, 2, 5-Trimethylcyclohexan-4-one	17.4	0.8989	1.44797	1.45010	1.45618	1.46112	(21)
$C_9H_{16}O$	1, 3, 5-Trimethyl-3-cyclohexen-5-ol	21.5	0.9140	1.46995	1.47251	1.47999	1.48608	(75)
$C_9H_{16}O$	*β*, *γ*-Pulenenol	18.5	0.9209	1.47113	1.47398	1.48116	1.48715	(50)
$C_9H_{16}O_2$	*α*, *β*-Nonylenic acid	15.6	0.9334	1.45267	1.45581*	1.46318	1.46956	(69)
$C_9H_{16}O_2$	Ethoxymethylenemethyl *tert.*-butyl ketone	14.2	0.9158	1.45697	1.46048	1.47052	1.47951(?)	(17)
$C_9H_{16}O_2$	Ethyl *α*, *β*-isoheptenate	15.2	0.8930	1.43538	1.43845*	1.44576	1.45226	(69)
$C_9H_{16}O_3$	*β*-Amyl-*β*-methoxyacrylic acid	60.8	0.9688	1.45506	1.45876	1.46841		(17)
$C_9H_{16}O_3$	*β*, *β*-Dimethyl-*δ*-acetylvaleric acid	14.3	1.0374	1.45646	1.45894	1.46516		(68)
$C_9H_{16}O_3$	Ethyl methylethylacetoacetate	18.7	0.9732	1.42399	1.42617	1.43154	1.43619	(9)
$C_9H_{16}O_4$	Azelaic acid	110.6	1.0291	1.42807		1.43576	1.44015	(130)
$C_9H_{16}O_4$	Diethyl dimethylmalonate	24.1	0.9917	1.40842	1.41049	1.41554	1.41972	(9)
$C_9H_{16}O_4$	Dimethyl diethylmalonate	24.5	1.0312	1.42330	1.42528	1.43052	1.43488	(9)
$C_9H_{16}O_4$	Diethyl pyrotartrate	19.8	1.0110	1.41717	1.41938*	1.42434	1.42857	(73,† 102)
$C_9H_{17}Br$	1, 1, 4-Trimethyl-4-bromocyclohexane	17.4	1.1700	1.47721	1.47995	1.48710	1.49311	(68)
$C_9H_{17}Br$	1, 3, 5-Trimethylcyclohexyl-1-bromide	11.1	1.1749	1.47951	1.48280	1.48971	1.49532	(55)
$C_9H_{17}Cl$	1, 3, 5-Trimethylcyclohexyl-1-chloride	15.2	0.9219	1.45182	1.45455	1.46035	1.46555	(55)
$C_9H_{17}Cl$	1, 3, 5-Trimethylcyclohexyl-5-chloride	13.9	0.9342	1.45566	1.45775	1.46412	1.46925	(21)
C_9H_{18}	1-Methyl-3-isopropylcyclopentane	15.2	0.7799	1.42744		1.43505	1.43947	(130)
C_9H_{18}	1, 1, 3-Trimethylcyclohexane	25.3	0.7866	1.43177	1.43385	1.43998	1.44453	(21)
C_9H_{18}	1, 2, 4-Trimethylcyclohexane	16.7	0.7848	1.43054		1.43829	1.44281	(130)
C_9H_{18}	1, 2, 5-Trimethylcyclohexane	16.9	0.7799	1.42860	1.43056	1.43632	1.44099	(21)
C_9H_{18}	1, 3, 5-Trimethylcyclohexane	13.1	0.7777	1.42971	1.43175	1.43764	1.44235	(21)
$C_9H_{18}O$	2, 6-Dimethyl-2-hepten-6-ol	17.6	0.8449	1.44633	1.44892	1.45572	1.46135	(71)
$C_9H_{18}O$	1-Isopropylcyclohexanol	15.5	0.9142	1.46064	1.46419	1.46891	1.47387	(46)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_9H_{18}O$	Pulenenol	16.5	0.9082	1.46064	1.46319	1.46961	1.47486	(50)
$C_9H_{18}O$	1, 1, 2-Trimethylcyclohexan-2-ol	19.9	0.9258	1.46542	1.46788	1.47367	1.47862	(67)
$C_9H_{18}O$	1, 2, 5-Trimethylcyclohexan-4-ol	19.2	0.8988	1.45639	1.45851	1.46459	1.46938	(21)
$C_9H_{18}O$	1, 3, 5-Trimethylcyclohexan-5-ol	16.3	0.8880	1.45108	1.45371	1.45921	1.46422	(55)
$C_9H_{18}O_4$	Ethyl α, α-diethoxypropionate	17.1	0.9792	1.41314	1.41508	1.42001	1.42419	(5)
$C_9H_{18}S_3$	Trithioacetone	23.5	1.0647	1.53634	1.54026*	1.54970		(73)
$C_9H_{19}N$	α-Isobutylpiperidine	21.7	0.8510	1.45274	1.45534	1.46158	1.46681	(106)
$C_9H_{19}N$	*N*-Methyl-*sym.*-copellidine	19.7	0.8231	1.44063	1.44299	1.44952	1.45471	(25)
$C_9H_{19}NO_2$	Ethyl *n*-hexylcarbamate	26.8	0.9226	1.43176	1.43412	1.43966	1.44416	(109)
$C_9H_{20}O_4$	Tetraethyl orthocarbonate	16.55	0.9198	1.39334	1.39518*	1.39954	1.40324	(28,† 108)
$C_9H_{21}N$	Tripropylamine	19.4	0.7573	1.41515	1.41756		1.42814	(106, 132)
$C_9H_{21}N_3$	Triformalethylamine	20.2	0.8941	1.45758	1.46044	1.46716	1.47287	(109)
$C_{10}H_6Cl_2$	1, 2-Dichloronaphthalene	48.5	1.3147	1.62571	1.63375	1.65620	1.67720	(48)
$C_{10}H_6Cl_2$	1, 4-Dichloronaphthalene	75.9	1.2997	1.61508	1.62282	1.64541	1.66589	(48)
$C_{10}H_6Cl_2$	1, 7-Dichloronaphthalene	99.5	1.2611	1.60165	1.60921	1.63070	1.64954	(145)
$C_{10}H_6Cl_2$	1, 8-Dichloronaphthalene	99.8	1.2924	1.61545	1.62357	1.64675	1.66555	(145)
$C_{10}H_7Br$	1-Bromonaphthalene	19.4	1.4868	1.64995	1.65876	1.68245	1.70433	(48, 111,† 112, 132)
$C_{10}H_7Cl$	1-Chloronaphthalene	21.6	1.1906	1.62365	1.63184	1.65456	1.67521	(48)
$C_{10}H_7Cl$	2-Chloronaphthalene	70.7	1.1377	1.60015	1.60787	1.62966		(48)
$C_{10}H_7ClO_3$	1-Phenyl-3-hydroxy-4, 4, 4-trichloro-1-butine	9.5	1.3541	1.58585	1.5917	1.60708	1.6176	(150)
$C_{10}H_7I$	1-Iodonaphthalene	14	1.7474	1.69547	1.70540	1.73295		(145)
$C_{10}H_7I$	2-Iodonaphthalene	99.4	1.6319	1.65665	1.66617	1.69264		(145)
$C_{10}H_8$	Naphthalene	99.6	0.9645	1.57472	1.58218	1.60328	1.62261	(48, 145†)
$C_{10}H_8O_2$	Methyl phenylpropiolate	30.5	1.0768		1.56006	1.5786	1.5952	(150)
$C_{10}H_9ClN_2$	1-Phenyl-5-methyl-3-chloropyrazole	15.3	1.2106	1.58046	1.58653*	1.60159	1.61512	(60)
$C_{10}H_9ClN_2$	1-Phenyl-3-methyl-5-chloropyrazole	16.2	1.1971	1.57516	1.58127*	1.59650	1.61021	(60)
$C_{10}H_9ClO_2$	1, 4-Dimethyl-1-chlorocoumaranone	18.65	1.2189	1.54953	1.55580	1.57465	1.59368	(19)
$C_{10}H_9ClO_2$	2, 2-Dimethyl-5-chlorocoumaranone	99.6	1.1484	1.51605	1.52238*	1.53943	1.55718	(40)
$C_{10}H_9N$	α-Methylquinoline	25.4	1.0536	1.60116	1.60909	1.63025	1.65024	(106)
$C_{10}H_9N$	γ-Methylquinoline	23.3	1.0709	1.59919	1.60695	1.62756	1.64664	(109)
$C_{10}H_9N$	α-Methylisoquinoline	20.5	1.0763	1.60173	1.60946	1.63009	1.64914	(109)
$C_{10}H_9N$	2-Naphthylamine	98.4	1.0614	1.63886	1.64927	1.67960	1.70193	(161)
$C_{10}H_9N$	*o*-Toluquinoline	20.8	1.0722	1.60810	1.61616	1.63773	1.65765	(109)
$C_{10}H_9N$	*m*-Toluquinoline	20.8	1.0670	1.60676	1.61486	1.63657	1.65677	(109)
$C_{10}H_9N$	*p*-Toluquinoline	23.0	1.0634	1.60608	1.61410	1.63584	1.65607	(109)
$C_{10}H_{10}$	Δ^1-Dihydronaphthalene	18.3	0.9976	1.57637	1.58317	1.60088	1.61720	(10)
$C_{10}H_{10}$	Δ^2-Dihydronaphthalene	32.7	0.9928	1.54992	1.55489	1.56752	1.57866	(10)
$C_{10}H_{10}$	γ-Methylindene	27	0.9682	1.55319	1.55907	1.57460	1.58865	(98)
$C_{10}H_{10}$	1-Phenylbutadiene	16	0.9309	1.60345	1.61283	1.64231	1.67190	(45,† 142)
$C_{10}H_{10}N_2$	1-Allylindazole	17.8	1.0687	1.57563	1.58246*	1.59964	1.61569	(60)
$C_{10}H_{10}N_2$	2-Allylindazole	15.0	1.0793	1.59298	1.60054*	1.62016	1.63876	(60)
$C_{10}H_{10}N_2$	1-Phenyl-5-methylpyrazole	12.4	1.0936	1.57925	1.58550*	1.60120	1.61534	(60)
$C_{10}H_{10}N_2O$	2-Acetyl-6-methylindazole	4.95	1.1623	1.57984	1.58676*	1.60479	1.62177	(33)
$C_{10}H_{10}N_2O_2$	Ethyl indazole-2-carboxylate	13.2	1.2060	1.56324	1.56939*	1.58514	1.59960	(29)
$C_{10}H_{10}O$	1, 4-Dimethylcoumarone	15.5	1.0346	1.54964	1.55537	1.57176	1.58632	(23)
$C_{10}H_{10}O$	1, 6-Dimethylcoumarone	14.4	1.0414	1.55061	1.55708	1.57261	1.58700	(23)
$C_{10}H_{10}O$	2, 4-Dimethylcoumarone	22.2	1.0347	1.54260	1.54846	1.56339	1.57683	(41)
$C_{10}H_{10}O$	1-Phenyl-3-hydroxy-1-butine	12.6	1.0363	1.56694	1.57305	1.58936	1.6034	(150)
$C_{10}H_{10}O$	Benzalacetone	45.9	1.0091	1.57466	1.58359	1.60999		(8)
$C_{10}H_{10}O$	Propenyl phenyl ketone	18.3	1.0298	1.55465	1.56091	1.57896	1.59544	(24)
$C_{10}H_{10}O$	β-Methylhydrindone	21.0	1.0653	1.54812	1.55338	1.56820	1.58139	(16)
$C_{10}H_{10}O$	α-Ketotetrahydronaphthalene	15.45	1.0989	1.56569	1.57118	1.58655	1.60032	(16)
$C_{10}H_{10}OS$	2-Ethoxythionaphthene	17.9	1.1591	1.59779	1.60495	1.62362	1.64098	(41)
$C_{10}H_{10}O_2$	Benzoylacetone	77.8	1.0560	1.55845	1.56775	1.59597	1.62646	(56)
$C_{10}H_{10}O_2$	Safrole	12	1.110	1.5369	1.5420	1.5557	1.5679	(128,† 132)
$C_{10}H_{10}O_2$	Isosafrole	12	1.128	1.5693	1.5763	1.5963	1.6155	(128)
$C_{10}H_{10}O_2$	2-Ethoxycoumarone	17.9	1.1061	1.54210	1.54773	1.56267	1.57619	(41)
$C_{10}H_{10}O_2$	1-Methyl-6-methoxycoumarone	14.25	1.1252	1.55977	1.56616	1.58186	1.58638	(23)
$C_{10}H_{10}O_2$	4-Methyl-2-methoxycoumarone	24.3	1.1074	1.54458	1.55036	1.56572	1.57971	(41)
$C_{10}H_{10}O_2$	6-Methylchromanone	57.1	1.1246	1.54889	1.55529	1.57285	1.59138	(19)
$C_{10}H_{10}O_2$	Methyl cinnamate	21.4	1.0881	1.56831	1.57661	1.59940	1.62155	(45, 107†)
$C_{10}H_{10}O_2$	Methyl allocinnamate	22.9	1.0761	1.54931	1.55616	1.57500	1.59262	(45, 107†)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_{10}H_{10}O_2$	Phenylvinyl acetate	22.9	1.0658	1.54255	1.54944	1.56930	1.58344	(43)
$C_{10}H_{10}O_3$	Propiophenone-*o*-carboxylic acid	99.1	1.1402	1.51327	1.51767	1.52944		(49)
$C_{10}H_{10}O_3$	Ethyl benzoylformate	25.1	1.1222	1.51373	1.51904		1.54458	(105)
$C_{10}H_{10}O_3$	Ethyl phenylglyoxylate	13.35	1.1255	1.51516	1.52008	1.53432	1.54722	(18)
$C_{10}H_{10}O_3$	Methyl benzoylacetate	24.7	1.1524	1.53083	1.53654	1.55145	1.56551	(17,† 50)
$C_{10}H_{10}O_4$	Dimethyl phthalate	20.8	1.1911	1.51141	1.51546	1.52735	1.53763	(49)
$C_{10}H_{10}O_4$	Monoethyl phthalate	22.0	1.1877	1.50490	1.50875	1.52028		(49)
$C_{10}H_{11}BrO$	α-Bromo-*n*-butyrophenone	13.25	1.3724	1.55996	1.56520	1.58035	1.59378	(65)
$C_{10}H_{11}BrO$	α-Bromoisobutyrophenone	14.4	1.3613	1.55425	1.55923	1.57369	1.58617	(65)
$C_{10}H_{11}ClO_2$	*o*-Isobutyro-*p*-chlorophenol	16.4	1.1958	1.54737	1.55379*	1.57182	1.59052	(40)
$C_{10}H_{11}Cl_3$	5-Chloro-1, 3-dimethyl-4(β, β-dichloroethyl)-benzene	16.1	1.2622	1.54788	1.55278	1.56427	1.57091	(4)
$C_{10}H_{11}Cl_3$	5-Chloro-1, 3-dimethyl-1-dichloromethyl-4-methene-2, 5-cyclohexadiene	17.3	1.2693	1.56255	1.56812	1.58230		(4)
$C_{10}H_{11}NO$	β-Methyl-μ-phenyloxazoline	22.9	1.0704	1.54065	1.54598		1.57247	(106)
$C_{10}H_{12}$	β-Butenylbenzene	21.0	0.9008	1.5269	1.5390	1.5545	1.5834	(132)
$C_{10}H_{12}$	α, β-Dimethylstyrene	19.7	0.9095	1.52930	1.53496	1.54895	1.56172	(43)
$C_{10}H_{12}$	β, β-Dimethylstyrene	19.6	0.8986	1.52185	1.52733	1.54105	1.55357	(43)
$C_{10}H_{12}$	β-Ethylstyrene	19.4	0.9097	1.53401	1.54019	1.55615	1.57083	(78)
$C_{10}H_{12}$	*p*-Methyl-α-methylstyrene	18.7	0.9022	1.52870	1.53447	1.54944	1.56306	(8)
$C_{10}H_{12}$	1, 2, 3, 4-Tetrahydronaphthalene	20.2	0.9729	1.54181	1.54614	1.55869	1.56914	(10, 145)
$C_{10}H_{12}Cl_2O_2$	*d*-Dehydrocamphoryl chloride	48.0	1.2189	1.50059	1.50433	1.51363	1.52171	(80)
$C_{10}H_{12}N_2$	Ethylethenyl-*o*-phenylenediamine	19.8	1.0726	1.57420	1.58023	1.59622	1.61054	(109)
$C_{10}H_{12}N_2$	1-Ethyl-3-methylindazole	16.6	1.0387	1.55806	1.56448*	1.58082	1.59657	(60)
$C_{10}H_{12}N_2$	1-Ethyl-5-methylindazole	16.1	1.0462	1.56359	1.56996*	1.58638	1.60180	(60)
$C_{10}H_{12}N_2$	2-Ethyl-3-methylindazole	16.6	1.0611	1.58084	1.58818*	1.60726	1.62593	(60)
$C_{10}H_{12}N_2$	2-Ethyl-5-methylindazole	15.8	1.0540	1.57535	1.58245*	1.60079	1.61840	(60)
$C_{10}H_{12}N_2$	1-Isopropylindazole	17.9	1.0387	1.55563	1.56184*	1.57729	1.59179	(60)
$C_{10}H_{12}N_2$	2-Isopropylindazole	15.4	1.0552	1.57515	1.58207*	1.60007	1.61712	(60)
$C_{10}H_{12}N_2$	1-Propylindazole	18.7	1.0405	1.55726	1.56350*	1.57919	1.59390	(60)
$C_{10}H_{12}O$	*asym.*-Aceto-*o*-xylene	15.5	1.0073	1.53558	1.54083	1.55578	1.56916	(89)
$C_{10}H_{12}O$	Aceto-*p*-xylene (2, 4-dimethylacetophenone)	18.55	0.9962	1.52479	1.53005	1.54349	1.55550	(41)
$C_{10}H_{12}O$	*o*-Allylanisole	14.35	0.9775	1.52149	1.52684	1.53919	1.55029	(47)
$C_{10}H_{12}O$	*o*-Allyl-*o*-cresol	15.2	1.0041	1.53580	1.54059	1.55359	1.56485	(47)
$C_{10}H_{12}O$	*o*-Allyl-*p*-cresol	15.75	1.0058	1.53772	1.54245	1.55571	1.56724	(47)
$C_{10}H_{12}O$	*o*-Cresol allyl ether	15.4	0.9687	1.51439	1.51876	1.53111	1.54160	(47)
$C_{10}H_{12}O$	1′, 5-Dimethyl-2-hydroxystyrene	18.2	1.0134	1.54635	1.55216	1.56638	1.57902	(14)
$C_{10}H_{12}O$	α-Ethoxystyrene	23.2	0.9673	1.52233	1.52775	1.54198	1.55480	(5)
$C_{10}H_{12}O$	β-Ethoxystyrene	21.2	0.9716	1.54346	1.55023	1.56838	1.58530	(5)
$C_{10}H_{12}O$	1′-Methyl-2-methoxystyrene	14.85	0.9882	1.53074	1.53575	1.55005	1.56252	(14)
$C_{10}H_{12}O$	1′-Methyl-3-methoxystyrene	11.8	0.9985	1.54020	1.54574	1.56124	1.57504	(14)
$C_{10}H_{12}O$	*o*-Propenyl-*p*-cresol	9.0	1.0291	1.57101	1.57768	1.59639	1.61410	(14)
$C_{10}H_{12}O$	*o*-Propenylphenylmethyl ether	15	0.9962	1.55318	1.55968	1.57766	1.59423	(14)
$C_{10}H_{12}O$	3, 4-Dimethylacetophenone	15.0	1.0085	1.53563	1.54128	1.55603	1.56944	(8)
$C_{10}H_{12}O$	Isopropyl phenyl ketone	16.6	0.9865	1.51445	1.51919	1.53172	1.54286	(8†, 43)
$C_{10}H_{12}O$	*p*-Propiotoluene	20.75	0.9899	1.52184	1.52714	1.54072	1.55289	(41)
$C_{10}H_{12}O$	*n*-Propyl phenyl ketone	18.25	0.9899	1.51581	1.52016	1.53298	1.54402	(16)
$C_{10}H_{12}O$	Anethole	11.5	0.999	1.5558	1.5624	1.5813	1.5988	(128, 156)
$C_{10}H_{12}O$	1, 4-Dimethylcoumarane	13.7	1.0145	1.52331	1.52792	1.54044	1.55162	(16)
$C_{10}H_{12}O$	1, 6-Dimethylcoumarane	13.8	1.0148	1.52509	1.52967	1.54211	1.55293	(16)
$C_{10}H_{12}O$	4, 6-Dimethylcoumarane	18.9	1.0261	1.53069	1.53579	1.54830	1.55968	(16)
$C_{10}H_{12}O$	Methylchavicol	11.5	0.979	1.5199	1.5244	1.5371	1.5476	(128)
$C_{10}H_{12}O$	5-Methylchromane	14.3	1.0374	1.53692	1.54205	1.55437	1.56547	(16)
$C_{10}H_{12}O_2$	*m*-Aceto-*p*-methoxytoluene (2-methoxy-5-methylacetophenone)	13.8	1.0693	1.53229	1.53769	1.55336	1.56802	(41)
$C_{10}H_{12}O_2$	*o*-Allylguaiacol	12.75	1.0724	1.53778	1.54259	1.55592	1.56734	(47)
$C_{10}H_{12}O_2$	Chavibetol	16	1.065	1.5349	1.5397	1.5527	1.5644	(128)
$C_{10}H_{12}O_2$	Guaiacyl allyl ether	12.75	1.0604	1.53203	1.53671	1.54987	1.56122	(47)
$C_{10}H_{12}O_2$	Eugenol	14.5	1.072	1.5385	1.5439	1.5574	1.5692	(128)
$C_{10}H_{12}O_2$	Isoeugenol	18	1.09	1.5617	1.5680	1.5868		(128)
$C_{10}H_{12}O_2$	*o*-Propio-*p*-cresol	13.8	1.0843	1.54211	1.54852	1.56760	1.58693	(41)
$C_{10}H_{12}O_2$	Ethyl phenylacetate	18.5	1.0348	1.49530	1.49921		1.51718	(105)
$C_{10}H_{12}O_2$	Ethyl *o*-toluate	21.6	1.0324	1.50229	1.50699	1.51849	1.52884	(41)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_{10}H_{12}O_2$	Ethyl *m*-toluate	21.6	1.0261	1.50042	1.50502	1.51670	1.52718	(41)
$C_{10}H_{12}O_2$	Ethyl *p*-toluate	18.2	1.0269	1.50418	1.50888	1.52106	1.53183	(8)
$C_{10}H_{12}O_3$	Ethyl *o*-methoxybenzoate	14.55	1.1156	1.51913	1.52379	1.53694	1.54856	(41)
$C_{10}H_{12}O_3$	Ethyl *m*-methoxybenzoate	16.4	1.1032	1.51195	1.51697	1.52955	1.54111	(41)
$C_{10}H_{12}O_3$	Ethyl *p*-methoxybenzoate	14.3	1.1091	1.52183	1.52739	1.54143	1.55436	(41)
$C_{10}H_{13}Cl_3O_2$	*d*-Chlorocamphoryl chloride	31.3	1.3221	1.50497	1.50797	1.51512	1.52133	(80)
$C_{10}H_{13}N$	γ-Methyltetrahydroquinoline	23.1	1.0191	1.57354	1.58015	1.59789	1.61213	(109)
$C_{10}H_{13}N$	*N*-Methyltetrahydroquinoline	17.3	1.0236	1.57620	1.58268	1.60057		(25)
$C_{10}H_{13}N$	*ar.*-Tetrahydro-α-naphthylamine	23.1	1.0542	1.58385	1.58964		1.61805	(106)
$C_{10}H_{13}N$	*ac.*-Tetrahydro-β-naphthylamine	22.2	1.0295	1.55570	1.56039		1.58354	(106)
$C_{10}H_{14}$	Cymene	23.8	0.8527	1.47925	1.48303	1.49222	1.50017	(98,† 134, 145, 148, 162)
$C_{10}H_{14}$	*p*-Diethylbenzene	16.2	0.8679	1.49499	1.49897	1.50993	1.51924	(20)
$C_{10}H_{14}$	1, 1-Dimethyl-4-ethene-2, 5-cyclohexadiene	15.15	0.8614	1.51072	1.51572	1.53015	1.54300	(89)
$C_{10}H_{14}$	*asym.*-Ethyl-*o*-xylene	15.05	0.8776	1.50103	1.50489	1.51606	1.52531	(89)
$C_{10}H_{14}$	Hexahydronaphthalene	18.4	0.9581	1.52879	1.53311	1.54397	1.55340	(155, 156)
$C_{10}H_{14}$	Isobutylbenzene	14.5	0.87163	1.4916	1.4957	1.5056	1.5141	(148)
$C_{10}H_{14}$	*o*-Methylisopropylbenzene	16.15	0.8789	1.49826	1.50206	1.51290	1.52185	(20)
$C_{10}H_{14}$	*m*-Methylisopropylbenzene	17.05	0.8628	1.49016	1.49385	1.50452	1.51336	(20)
$C_{10}H_{14}$	*p*-Methylisopropylbenzene	15.0	0.8631	1.49105	1.49474	1.50537	1.51449	(20)
$C_{10}H_{14}$	*o*-Methylpropylbenzene	15.75	0.8770	1.49765	1.50139	1.51218	1.52125	(20)
$C_{10}H_{14}$	*m*-Methylpropylbenzene	17.0	0.8648	1.49262	1.49640	1.50738	1.51646	(20,† 61)
$C_{10}H_{14}$	*p*-Methylpropylbenzene	18.8	0.8620	1.49278	1.49655	1.50765	1.51687	(20, 61†)
$C_{10}H_{14}$	1, 2, 3, 4-Tetramethylbenzene	16.0	0.9044	1.51621	1.52031	1.53192	1.54189	(20)
$C_{10}H_{14}$	1, 1, 2-Trimethyl-4-methene-2, 5-cyclohexadiene	10.7	0.8735	1.51331	1.51813	1.53213	1.54435	(89)
$C_{10}H_{14}Cl_2O$	1-Ethyl-4-methyl-4-dichloromethyl-1-cyclohexen-3-one	17	1.1953	1.51908	1.52331	1.53285	1.54166	(52)
$C_{10}H_{14}Cl_2O$	1-Ethyl-4-methyl-4-dichloromethyl-5-cyclohexen-3-one	17.4	1.1671	1.49967	1.50292	1.51067	1.51723	(52)
$C_{10}H_{14}Cl_2O$	1, 4, 5-Trimethyl-1-dichloromethyl-3-cyclohexen-2-one	19.8	1.1971	1.52013	1.52392	1.53417	1.54298	(88)
$C_{10}H_{14}Cl_2O_2$	*d-cis*-Camphoryl chloride	19.9	1.2449	1.49846	1.50133	1.50842	1.51443	(80)
$C_{10}H_{14}Cl_2O_2$	*l-trans*-Camphoryl chloride	20.7	1.2269	1.49593	1.49880	1.50606	1.51206	(80)
$C_{10}H_{14}N_2$	Nicotine	22.4	1.0121	1.51980	1.52392		1.54387	(106)
$C_{10}H_{14}N_2$	Metanicotine	19.7	1.0017	1.54906	1.55509	1.57059	1.58475	(106)
$C_{10}H_{14}N_2O$	2-Acetyl-5-methyltetrahydroindazole	17.9	1.0807	1.51796	1.52228*	1.53290	1.54247	(60)
$C_{10}H_{14}N_2O_2$	Ethyl 1-allyl-3-methylpyrazole-5-carboxylate	16.0	1.0495	1.48654	1.49081*	1.50116	1.51096	(38)
$C_{10}H_{14}N_2O_2$	Ethyl 1-allyl-5-methylpyrazole-3-carboxylate	15.9	1.0803	1.49947	1.50362*	1.51376	1.52350	(38)
$C_{10}H_{14}O$	*p*-Tolyldimethyl carbinol	13.5	0.9844	1.51831	1.52215	1.53353	1.54298	(145)
$C_{10}H_{14}O$	*asym.*-Ethoxy-*m*-xylene	13.95	0.9487	1.50297	1.50692	1.51874	1.52872	(16)
$C_{10}H_{14}O$	*vic.*-Ethoxy-*m*-xylene	13.9	0.9420	1.49337	1.49694	1.50780	1.51666	(16)
$C_{10}H_{14}O$	Hemimellitenyl methyl ether	22.9	0.9739	1.51846	1.52272	1.53470	1.54520	(47)
$C_{10}H_{14}O$	Mesityl methyl ether	14.4	0.9531	1.50161	1.50553	1.51672	1.52615	(16, 47†)
$C_{10}H_{14}O$	Pseudocumenyl methyl ether	13.9	0.9690	1.51777	1.52203	1.53433	1.54455	(47)
$C_{10}H_{14}O$	*asym.*-*o*-Xylenyl ethyl ether	14.95	0.9545	1.50770	1.51194	1.52363	1.53330	(47)
$C_{10}H_{14}O$	*vic.*-*o*-Xylenyl ethyl ether	15.9	0.9559	1.50790	1.51187	1.52361	1.53342	(47)
$C_{10}H_{14}O$	*asym.*-*m*-Xylenyl ethyl ether	13.95	0.9487	1.50297	1.50692	1.51874	1.52872	(16,† 47)
$C_{10}H_{14}O$	*sym.*-*m*-Xylenyl ethyl ether	15.2	0.9437	1.50305	1.50705	1.51862	1.52814	(47)
$C_{10}H_{14}O$	*vic.*-*m*-Xylenyl ethyl ether	13.9	0.9420	1.49337	1.49694	1.50780	1.51666	(16,† 47)
$C_{10}H_{14}O$	*p*-Xylenyl ethyl ether	12.65	0.9451	1.50288	1.50699	1.51867	1.52827	(47)
$C_{10}H_{14}O$	Carvacrol	18.6	0.9774	1.52009	1.52450	1.53581	1.54550	(47, 110†)
$C_{10}H_{14}O$	Thymol	24.4	0.9689	1.51453	1.51893	1.53012	1.53998	(156, 161)
$C_{10}H_{14}O$	Carvone	18.7	0.9611	1.49554	1.49935	1.50908	1.51780	(43)
$C_{10}H_{14}O$	*d*-Carvone	18.2	0.9626	1.49614	1.49994	1.50978	1.51824	(110)
$C_{10}H_{14}O$	Eucarvone	21.2	0.9840	1.50339	1.50872	1.52341	1.53794	(16)
$C_{10}H_{14}O_2$	1-Methyl-4-ethyl-1, 3-cyclohexadiene-3-carboxylic acid	14.8	1.0284	1.49496	1.49887	1.50831	1.51684	(54)
$C_{10}H_{14}O_2$	Methyl 1, 4-dimethyl-1, 3-cyclohexadiene-2-carboxylate	16.8	0.9976	1.47338	1.47681	1.48544	1.49300	(45)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_{10}H_{14}O_2$	Methyl 3, 6-dimethyl-2, 6-cyclohexadienecarboxylate	18	0.9965	1.47358	1.47643	1.48458	1.49173	(51)
$C_{10}H_{14}O_4$	Diethyl muconate	99.1	0.9829	1.46178	1.46755*	1.48259	1.49695	(27)
$C_{10}H_{15}N$	Diethylaniline	22.3	0.9325	1.53509	1.54105		1.57077	(106,† 145)
$C_{10}H_{15}NO$	1-Propyl-1-cyanocyclohexan-2-one	20.1	0.9968	1.46459	1.46721*	1.47320	1.47836	(39)
$C_{10}H_{15}NO_2$	Ethyl α-cyano-Δ^1-isoheptenate	19.7	0.9666	1.45198	1.45502	1.46340	1.47037	(58)
$C_{10}H_{15}NO_3$	Amyl α-acetocyanoacetate	20	1.0328	1.4639	1.4676	1.4772	1.4857	(138)
$C_{10}H_{15}NO_4$	Diethyl ethylcyanomalonate	20	1.0521	1.4245	1.4267	1.4319	1.4363	(138)
$C_{10}H_{16}$	2, 6-Dimethyl-3, 5, 7-octatriene	15.6	0.8119	1.54403	1.54558	1.57682	1.60086	(45)
$C_{10}H_{16}$	*d*-Limonene	14.7	0.8468	1.47172	1.47489	1.48277	1.49062	(78,† 120, 125)
$C_{10}H_{16}$	*l*-Limonene	20.5	0.8407	1.47157	1.47468	1.48256	1.48924	(120)
$C_{10}H_{16}$	1-Methyl-4-isopropyl-1, 3-cyclohexadiene	19.4	0.8361	1.47359	1.47810	1.48837	1.49795	(52)
$C_{10}H_{16}$	Myrcene	15.8	0.8082	1.46684		1.48061	1.48923	(43)
$C_{10}H_{16}$	*d*-α-Pinene	18.05	0.8594	1.46354	1.46634	1.47322	1.47925	(78)
$C_{10}H_{16}$	*l*-α-Pinene	16.25	0.8621	1.46517	1.46803	1.47509	1.48098	(78)
$C_{10}H_{16}$	*l*-Pinene	23.5	0.8570	1.46252	1.46526	1.47202	1.47779	(98)
$C_{10}H_{16}$	Sabinene	17.0	0.8422	1.46428	1.46738	1.47514	1.48196	(78)
$C_{10}H_{16}$	Sylvestrene	17.2	0.8486	1.47380	1.47717	1.48505	1.49245	(78,† 125)
$C_{10}H_{16}Cl_2O_2$	Sebacyl chloride	18.3		1.46570	1.46836	1.47503		(80)
$C_{10}H_{16}N_2$	1-Ethyl-5-methyltetrahydroindazole	21.4	0.9837	1.49761	1.50103*	1.50940	1.51637	(60)
$C_{10}H_{16}N_2$	2-Ethyl-5-methyltetrahydroindazole	19.8	0.9866	1.49678	1.50009*	1.50818	1.51513	(60)
$C_{10}H_{16}N_2$	2-Ethyl-7-methyltetrahydroindazole	14.4	0.9954	1.50660	1.51011*	1.51854	1.52566	(60)
$C_{10}H_{16}O$	*d*-Carone	18.8	0.9577	1.47597	1.47877	1.48560	1.49122	(110)
$C_{10}H_{16}O$	Carvenone	16.7	0.9300	1.48028	1.48463	1.49304	1.50134	(43,† 44, 110)
$C_{10}H_{16}O$	Carvotanacetone	20	0.9351	1.47730	1.48056	1.48887	1.49606	(43,† 110)
$C_{10}H_{16}O$	Dihydrocarvone	17.5	0.9273	1.46884	1.47175	1.47870	1.48449	(110)
$C_{10}H_{16}O$	Dihydroeucarvone	18.9	0.9232	1.46455	1.46737	1.47406	1.47965	(110)
$C_{10}H_{16}O$	Fenchone	14.5	0.9488	1.46232		1.47076	1.47571	(130)
$C_{10}H_{16}O$	Pulegone	18.3	0.9371	1.48328	1.48705	1.49623	1.50437	(43)
$C_{10}H_{16}O$	Tanacetone	17.6	0.9182	1.44986	1.45220	1.45808	1.46279	(110)
$C_{10}H_{16}O$	1, 1, 2, 4-Tetramethyl-2, 5-cyclohexadien-4-ol	10.1	0.9332	1.48376	1.48685	1.49502	1.50176	(89)
$C_{10}H_{16}O_2$	1, 3-Dimethyl-4-cyclohexene-5-acetic acid	20.3	0.9945	1.47428	1.47731	1.48449	1.49068	(76, 84)
$C_{10}H_{16}O_2$	Geranic acid	20.2	0.9518	1.48284	1.48695	1.49758	1.50690	(44)
$C_{10}H_{16}O_2$	Ethyl cyclohexene-1-acetate	16.2	0.9892	1.46422	1.46906	1.47414	1.48017	(46)
$C_{10}H_{16}O_2$	Ethyl cyclohexylideneacetate	16.9	0.9825	1.47721	1.48083	1.48963	1.49737	(46)
$C_{10}H_{16}O_2$	Ethyl diallylacetate	19.1	0.8976	1.43354	1.43638	1.44312	1.44888	(71)
$C_{10}H_{16}O_2$	Methyl 3-methylcyclohexeneacetate	15.7	0.9692	1.45524	1.45822		1.47071	(46)
$C_{10}H_{16}O_2$	Methyl 4-methylcyclohexeneacetate	16.9	0.9614	1.45132	1.45402	1.46149	1.46648	(46)
$C_{10}H_{16}O_2$	Methyl 2-methylcyclohexylideneacetate	14.2	0.9767	1.47681	1.48072	1.48991	1.49802	(46)
$C_{10}H_{16}O_2$	Methyl 3-methylcyclohexylideneacetate	15.5	0.9752	1.47534	1.47926	1.48845	1.49668	(46)
$C_{10}H_{16}O_2$	Methyl 4-methylcyclohexylideneacetate	16.9	0.9702	1.47200	1.47583	1.48506	1.49329	(46)
$C_{10}H_{16}O_2$	Methyl isolauronolate	17.3	0.97207	1.46634	1.46970	1.47795	1.48517	(43)
$C_{10}H_{16}O_2$	Methyl 1-4-dimethyl-3-cyclohexene-3-carboxylate	19	0.9708	1.45656	1.45922	1.46585	1.47142	(54)
$C_{10}H_{16}O_2$	Ethyl amylpropiolate	11.5	0.9207	1.44842	1.45142	1.4583	1.4644	(150)
$C_{10}H_{16}O_2$	Methyl hexylpropiolate	12.5	0.9238	1.44915	1.45182	1.4588	1.4647	(150)
$C_{10}H_{16}O_2$	Methyl α-cyclohexenepropionate	18.3	0.9864	1.46373	1.46648	1.47321	1.47885	(46)
$C_{10}H_{16}O_2$	Ethyl β, δ-dimethylsorbate	18.5	0.9343	1.48301	1.48823*	1.50175	1.51447	(27)
$C_{10}H_{16}O_2$	Ethyl α-ethylsorbate	15.3	0.9345	1.49076	1.49653	1.51162	1.52605	(27)
$C_{10}H_{16}O_2$	Ethyl Δ^1-tetrahydro-*m*-toluate	18.45	0.9758	1.46413	1.46748*	1.47473	1.48126	(26)
$C_{10}H_{16}O_4$	Diethyl *cis*-β-methylglutaconate	21.2	1.0332	1.44858	1.45161*	1.45918	1.46562	(73)
$C_{10}H_{16}O_4$	Diethyl *trans*-β-methylglutaconate	21.2	1.0330	1.44828	1.45147*	1.45883	1.46538	(73)
$C_{10}H_{16}O_4$	Diethyl isopropylidenemalonate	17.0	1.0284	1.44562	1.44857	1.45602	1.46233	(45)
$C_{10}H_{16}O_4$	Dipropyl fumarate	20	1.0220	1.44133	1.44347	1.45148	1.45771	(45,† 144)
$C_{10}H_{16}O_4$	Dipropyl maleate	20	1.0290	1.44092	1.44372	1.45053	1.45630	(45,† 144)
$C_{10}H_{16}O_5$	Diethyl ethoxymethylenemalonate	15.3	1.0811	1.45966	1.46307	1.47235	1.48060	(17)
$C_{10}H_{16}O_5$	Diethyl propionylmalonate	16.4	1.0791	1.44102	1.44358	1.45095	1.45701	(34,† 56)
$C_{10}H_{16}O_5$	Ethyl α-methyl-β-hydroxycarbethoxy-α, β-crotonate	17.6	1.0799	1.43829	1.44091		1.45308	(43, 105†)
$C_{10}H_{16}O_6$	Triethyl methanetricarboxylate	16.15	1.1084	1.42558	1.42748	1.43313	1.43762	(35)
$C_{10}H_{17}N$	1-Cyano-2-methyl-5-isopropylcyclopentane	16.2	0.8814	1.44751		1.45538	1.45994	(130)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_{10}H_{17}NO$	α-Fencholamide	117.9	0.9331	1.46216		1.47226	1.47833	(130)
$C_{10}H_{17}NO_2$	Acetyltropein	15.4	1.0627	1.47456	1.47687	1.48321		(25)
$C_{10}H_{17}NO_3$	Methyl *l*-ecgoninate	20.5	1.1468	1.48474	1.48765			(25)
$C_{10}H_{18}$	Decahydronaphthalene	18.0	0.8952	1.47789	1.48035	1.48638	1.49154	(10)
$C_{10}H_{18}$	Menthene	20.4	0.8060	1.44562	1.44813	1.45484	1.46026	(98)
$C_{10}H_{18}$	1, 2, 4, 5-Tetramethyl-4-cyclohexene	16.5	0.8199	1.45617	1.45880	1.46597	1.47192	(21)
$C_{10}H_{18}O$	Diallylpropyl carbinol	21.1	0.8645	1.45394	1.45677	1.46378	1.46945	(141)
$C_{10}H_{18}O$	Diisovaleric aldehyde	17.4	0.8542	1.44327		1.45463	1.46162	(43)
$C_{10}H_{18}O$	$\Delta^{4,8}$-Menthen-1-ol	80	0.8948	1.46277		1.47297	1.47904	(130)
$C_{10}H_{18}O$	$\Delta^{8,9}$-Menthen-1-ol	79.8	0.8703	1.44612		1.45526	1.46059	(130)
$C_{10}H_{18}O$	1, 1, 4, 4-Tetramethylcyclohexan-2-one	14.3	0.8931	1.44635	1.44849	1.45452	1.45957	(68)
$C_{10}H_{18}O_2$	1, 3-Dimethylcyclohexanyl 5-acetate	20.2	0.9277	1.43526	1.43758	1.44312	1.44771	(55)
$C_{10}H_{18}O_3$	Ethyl diethylacetoacetate	17.2	0.9707	1.43031	1.43266	1.43806	1.44269	(6,† 9, 105)
$C_{10}H_{18}O_3$	Methyl β-amyl-β-methoxyacrylate	23.1	0.9610	1.45157	1.45494	1.46328	1.47076	(17)
$C_{10}H_{18}O_4$	Diethyl *asym.*-dimethylsuccinate	14.0	0.9988	1.42194	1.42406*	1.42925	1.43343	(73)
$C_{10}H_{18}O_4$	Diethyl *fum.-sym.*-dimethylsuccinate	14.9	1.000	1.42157	1.42377*	1.42887	1.43312	(73)
$C_{10}H_{18}O_4$	Diethyl *mal.-sym.*-dimethylsuccinate	14.3	1.0015	1.42355	1.42568*	1.43084	1.43515	(73)
$C_{10}H_{18}O_4$	Diethyl methylethylmalonate	18.2	0.9970	1.41696	1.41896	1.42417	1.42837	(9)
$C_{10}H_{19}Cl$	1, 2, 4, 5-Tetramethylcyclohexyl 4-chloride	13.95	0.9406	1.46288	1.46515	1.47150	1.47655	(21)
$C_{10}H_{19}N$	Camphylamine	17.8	0.8736	1.46992	1.47284		1.48555	(106)
$C_{10}H_{19}NO$	1-Methyl-3-isopropylcyclopentane-1-carboxamide	108.2	0.9072	1.44683		1.45543	1.46042	(130)
$C_{10}H_{20}$	Decene	17	0.7721	1.4357	1.4385	1.4447	1.4500	(148,† 155, 156)
$C_{10}H_{20}$	1, 2, 4, 5-Tetramethylcyclohexane	13.1	0.7910	1.43517	1.43718	1.44307	1.44772	(21)
$C_{10}H_{20}O$	2, 6-Dimethyl-2-octen-6-ol	15.9	0.8576	1.45275	1.45552	1.46216	1.46737	(71)
$C_{10}H_{20}O$	Allyldipropyl carbinol	19.0	0.8446	1.44201	1.44452	1.45070	1.45575	(141)
$C_{10}H_{20}O$	1, 1, 4, 4-Tetramethylcyclohexan-2-ol	30.2	0.8935	1.45471	1.45714	1.46295	1.46777	(68)
$C_{10}H_{20}O$	1, 2, 4, 5-Tetramethylcyclohexan-4-ol	18.1	0.8983	1.45738	1.45945	1.46543	1.47021	(21)
$C_{10}H_{20}O_2$	Isoamyl isovalerate	19.0	0.85840	1.41095	1.41311	1.41814	1.42335	(125)
$C_{10}H_{21}Br$	*n*-Decyl bromide	20	1.0683	1.45251	1.45504	1.46116	1.46636	(163)
$C_{10}H_{21}Cl$	*n*-Decyl chloride	20	0.8696	1.43573	1.43799	1.44346	1.44794	(163)
$C_{10}H_{21}I$	*n*-Decyl iodide	20	1.2564	1.48269	1.48589	1.49377	1.50051	(163)
$C_{10}H_{21}N$	Isoamyl isoamylideneamine	18.9	0.7724	1.42325	1.42576	1.43177	1.43676	(109)
$C_{10}H_{22}$	Decane	14.9	0.7278	1.4088	1.4108	1.4160	1.4200	(148)
$C_{10}H_{22}$	Diisoamyl	23.2	0.7214	1.40502	1.40702	1.41215	1.41651	(131)
$C_{10}H_{22}O$	*n*-Decyl alcohol	20	0.8300	1.43503	1.43719	1.44247	1.44688	(163)
$C_{10}H_{22}S$	Isoamyl sulfide	20	0.84314	1.44966	1.45238	1.45889	1.46447	(153, 154)
$C_{10}H_{23}N$	Diisoamylamine	21.1	0.7672	1.42059	1.42289		1.43317	(106)
$C_{11}H_8O$	α-Naphthaldehyde	19.3	1.1490	1.64404	1.65464	1.68490	1.71624	(145)
$C_{11}H_{10}$	1-Methylnaphthalene	99.2	0.9656	1.57353	1.58077	1.60159	1.62067	(48)
$C_{11}H_{10}$	2-Methylnaphthalene	39.9	0.9939	1.59499	1.60263	1.62395	1.64284	(48)
$C_{11}H_{10}O$	Methyl-α-naphthol	13.9	1.0964	1.61474	1.62322	1.64597	1.66763	(155, 156)
$C_{11}H_{10}O_2$	δ-Phenyl-Δ^1-angelolactone	14.9	1.1537	1.56004	1.56580*	1.58011	1.59295	(28)
$C_{11}H_{10}O_2$	δ-Phenyl-Δ^2-angelolactone	15.7	1.1173	1.52622	1.53055*	1.54129		(28)
$C_{11}H_{10}O_2$	Ethyl phenylpropiolate	13	1.0632	1.5500	1.5566	1.5738	1.5897	(150)
$C_{11}H_{10}O_2S$	Ethyl thionaphthene-2-carboxylate	55.4	1.1720	1.58370	1.59178*	1.61332	1.63375	(59)
$C_{11}H_{10}O_3$	Ethyl coumarilate	32.2	1.1618	1.55453	1.56194	1.58119	1.60020	(41)
$C_{11}H_{11}ClN_2$	1-Benzyl-3-methyl-4-chloropyrazole	14.2	1.1621	1.55323	1.55818*	1.57043		(38)
$C_{11}H_{11}ClN_2$	1-Benzyl-5-methyl-4-chloropyrazole	14.2	1.1847	1.55752	1.56254	1.57476	1.58531	(38)
$C_{11}H_{11}ClO_2$	Ethyl *o*-chlorocinnamate	21.1	1.1683	1.55782	1.56447	1.58439	1.60310	(47)
$C_{11}H_{12}$	1-Phenyl-1, 3-pentadiene	13	0.9384	1.60167	1.61114	1.64065	1.67038	(45,† 142)
$C_{11}H_{12}N_2$	1-Allyl-5-methylindazole	12.2	1.0549	1.57276	1.57932*	1.59620	1.61199	(60)
$C_{11}H_{12}N_2$	2-Allyl-5-methylindazole	16.6	1.0528	1.58373	1.59100	1.60987	1.62824	(60)
$C_{11}H_{12}N_2$	1-Benzyl-3-methylpyrazole	14.2	1.0541	1.55147	1.55643*	1.56872	1.57938	(60)
$C_{11}H_{12}N_2$	1-Phenyl-2, 4-dimethylpyrazole	19.3	1.0573	1.56801	1.57384	1.58961	1.60360	(106)
$C_{11}H_{12}N_2$	1-Phenyl-3, 4-dimethylpyrazole	19.8	1.0606	1.58023	1.58739*	1.60613	1.62376	(60)
$C_{11}H_{12}N_2$	1-Phenyl-3, 5-dimethylpyrazole	16.6	1.0586	1.56897	1.57503*	1.59047	1.60435	(60)
$C_{11}H_{12}N_2$	1-Phenyl-4, 5-dimethylpyrazole	18.1	1.0665	1.56933	1.57539*	1.59066	1.60437	(60)
$C_{11}H_{12}N_2O$	2-*n*-Butyrylindazole (stable)	33.5	1.1090	1.55242	1.55854	1.57460	1.58971	(33)
$C_{11}H_{12}N_2O$	2-Isobutyrylindazole (stable)	12.8	1.1136	1.55902	1.56534*	1.58140	1.59652	(33)
$C_{11}H_{12}O$	α-Benzalmethyl ethyl ketone	50.3	0.9875	1.55991	1.56838	1.59237		(8)
$C_{11}H_{12}O$	γ-Benzalmethyl ethyl ketone	45.3	1.0018	1.56143	1.56907	1.59084		(8)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_{11}H_{12}O$	1-Keto-7-methyl-1, 2, 3, 4-tetrahydronaphthalene	35.0	1.0569	1.55168	1.55674	1.57160	1.58479	(145,† 146)
$C_{11}H_{12}O$	*ac.*-2-Methyl-1-ketotetrahydronaphthalene	20.9	1.0600	1.54669	1.55154	1.56542	1.57764	(146)
$C_{11}H_{12}O$	2, 2-Dimethyl-α-chromene	14.4	1.0183	1.54744	1.55372	1.57018	1.58565	(23)
$C_{11}H_{12}O$	4, 6-Dimethyl-α-chromene	19.9	1.0420	1.55610	1.56231	1.57851	1.59374	(23)
$C_{11}H_{12}O$	β, β-Dimethyl-α-hydrindone	13.9	1.0313	1.53587	1.54078	1.55470	1.56714	(16)
$C_{11}H_{12}O$	3, 3-Dimethyl-1-hydrindone	14.25	1.0320	1.54026	1.54525	1.55936	1.57182	(24)
$C_{11}H_{12}O$	1-Phenyl-3-hydroxy-1-pentine	13	1.0138	1.55764	1.56333	1.57861	1.59206	(150)
$C_{11}H_{12}O$	1, 2, 4-Trimethylcoumarone	14	1.0267	1.54685	1.55332	1.56865	1.58330	(23)
$C_{11}H_{12}O_2$	*p*-Crotonylanisole	11.7	1.0906	1.57861	1.58723*	1.61003	1.63306	(30)
$C_{11}H_{12}O_2$	α-Methyl-β-acetoxystyrene	15.2	1.0574	1.53680	1.54278	1.55801	1.57204	(14)
$C_{11}H_{12}O_2$	1′-Methyl-2-acetoxystyrene	13.5	1.0481	1.51327	1.51754	1.52983	1.54030	(14)
$C_{11}H_{12}O_2$	1′-Methyl-3-acetoxystyrene	14.1	1.0612	1.52765	1.53252	1.54651	1.55872	(14)
$C_{11}H_{12}O_2$	4-Methyl-2-ethoxycoumarone	16.6	1.0826	1.53846	1.54395	1.55856	1.57184	(41)
$C_{11}H_{12}O_2$	1, 4-Dimethyl-2-methoxycoumarone	19.0	1.0806	1.53828	1.54403	1.56052	1.57635	(72)
$C_{11}H_{12}O_2$	Methyl-*o*-coumarketone methyl ether	61.4	1.0534	1.57525	1.58591	1.61640		(14)
$C_{11}H_{12}O_2$	Benzoylacetone *O*-methyl ether	16	1.0679	1.55296	1.55981	1.57810	1.59624	(17)
$C_{11}H_{12}O_2$	2, 5-Dimethyl-7-hydroxyhydrindone	13.6	1.1293	1.56311	1.56966*	1.58663	1.60329	(30)
$C_{11}H_{12}O_2$	2-Methyl-6-methoxyhydrindone	16.9	1.1188	1.55310	1.55884	1.57529		(37)
$C_{11}H_{12}O_2$	1, 1, 4-Trimethylcoumaranone	19.3	1.0730	1.53433	1.54040	1.55877	1.57776	(11, 19)†
$C_{11}H_{12}O_2$	1, 3, 5-Trimethylcoumaranone	19.2	1.0987	1.55106	1.55739	1.57622	1.59485	(19)
$C_{11}H_{12}O_2$	2, 2, 7-Trimethylcoumaranone	100.6	1.0010	1.50063	1.50668*	1.52279	1.54003	(40)
$C_{11}H_{12}O_2$	Propionylacetophenone	20.0	1.0774	1.57455	1.58400	1.61197	1.64247	(56)
$C_{11}H_{12}O_2$	Methylbenzoylacetone	20	1.0798	1.53275	1.53834	1.55336	1.56744	(17,† 56)
$C_{11}H_{12}O_2$	Ethyl atropate	16.1	1.0508	1.52151	1.52605	1.53871	1.54996	(45)
$C_{11}H_{12}O_2$	Ethyl allocinnamate	22.05	1.0465	1.53769	1.54416	1.56140	1.57743	(45, 79, 107†)
$C_{11}H_{12}O_2$	*trans*-Ethyl cinnamate	20	1.0490	1.55216	1.55982	1.58043	1.60053	(14, 45, 95, 107†)
$C_{11}H_{12}O_2$	Methyl β-methylcinnamate	37.8	1.0544	1.54435	1.55045	1.56883	1.58592	(14)
$C_{11}H_{12}O_2$	Methyl allo-β-methylcinnamate	38.1	1.0373	1.52274	1.52755	1.54200	1.55457	(14)
$C_{11}H_{12}O_2$	Methyl *p*-methylcinnamate	56.6	1.0273	1.54983	1.55807	1.58130(?)		(14)
$C_{11}H_{12}O_3$	Ethyl hydrocoumarilate	13.9	1.1542	1.52103	1.52502	1.53617	1.54577	(16)
$C_{11}H_{12}O_3$	1, 4-Dimethyl-1-methoxycoumaranone	22.6	1.1299	1.53188	1.53827	1.55672	1.57577	(12)
$C_{11}H_{12}O_3$	1-Methyl-4-methoxycoumarone methyl ether	17.4	1.1470	1.54711	1.55313	1.57057	1.58791	(72)
$C_{11}H_{12}O_3$	Methyl *p*-cresyl diketone methyl ether	16.0	1.1193	1.53188	1.53780	1.55554		(18)
$C_{11}H_{12}O_3$	α-Ethyl-α-methoxyphthalide	20.35	1.1323	1.51533	1.51986	1.53104	1.54104	(49)
$C_{11}H_{12}O_3$	α-Acetoxypropiophenone	19.7	1.1126	1.51120	1.51533	1.52729		(15)
$C_{11}H_{12}O_3$	Ethyl benzoylacetate	16	1.1185	1.52560	1.53115	1.54587	1.55980	(17,† 56)
$C_{11}H_{12}O_3$	Methyl *o*-methoxycinnamate	16.7	1.1368	1.57609	1.58535	1.61182	1.64016	(14)
$C_{11}H_{12}O_3$	Methyl β-methoxycinnamate	24.7	1.1179	1.54337	1.54971	1.56637	1.58186	(14)
$C_{11}H_{12}O_3$	Methyl propiophenone-*o*-carboxylate	15.2	1.1288	1.51936	1.52396	1.53577	1.54594	(49)
$C_{11}H_{12}O_3$	Methyl β-phenylmethylglycidate	19.9	1.1230	1.50913	1.51319	1.52342	1.53246	(16)
$C_{11}H_{13}BrO_2$	*o*-(α-Bromoisobutyro)-*p*-cresol	22.3	1.3669	1.56400	1.57141	1.59245	1.61218	(11)
$C_{11}H_{13}Cl$	4-Methyl-α-ethyl-β-chlorostyrene	19.85	1.0362	1.53639	1.54177	1.55548	1.56777	(13)
$C_{11}H_{14}$	*ar.*-2-Methyltetrahydronaphthalene	15.1	0.9541	1.53316	1.53719	1.54907	1.55897	(146)
$C_{11}H_{14}$	1-Phenyl-2-pentene	16.2	0.8884	1.50444	1.50890	1.51986	1.52958	(78)
$C_{11}H_{14}$	α, α, β-Trimethylstyrene	19.8	0.8970	1.51494	1.51997	1.53217	1.54311	(43)
$C_{11}H_{14}Cl_2$	1-Dichloro-2-*p*-tolylbutane	19.8	1.1117	1.52404	1.52827	1.53900	1.54787	(13)
$C_{11}H_{14}Cl_2$	1, 2, 3-Trimethyl-5-(β, β-dichloroethyl)-benzene	21.8	1.1424	1.53900	1.54310	1.55494		(89)
$C_{11}H_{14}N_2$	1-*n*-Butylindazole	17.2	1.0215	1.54889	1.55466*	1.56943	1.58663	(60)
$C_{11}H_{14}N_2$	2-*n*-Butylindazole	17.1	1.0274	1.55743	1.56358*	1.57944	1.59688	(60)
$C_{11}H_{14}N_2$	2, 3-Diethylindazole	19.1	1.0395	1.57254	1.57952*	1.59762	1.61596	(60)
$C_{11}H_{14}O$	α-*p*-Butenylanisole	19	0.9797	1.5426	1.5559	1.5733	1.6096	(132)
$C_{11}H_{14}O$	Ethylchavicol	12.2	0.961	1.5133	1.5179	1.5299	1.5400	(128)
$C_{11}H_{14}O$	Isobutyl phenyl ketone	15.3	0.9710	1.50917	1.51385	1.52574	1.53611	(8)
$C_{11}H_{14}O$	*tert.*-Butyl phenyl ketone	19.2	0.9678	1.50427	1.50857	1.51971	1.52964	(8)
$C_{11}H_{14}O$	2, 4, 5-Trimethylacetophenone	14.9	1.0037	1.53572	1.54111	1.55525	1.56815	(8)
$C_{11}H_{14}O$	*p*-Isobutyrotoluene	21.2	0.9682	1.51366	1.51873	1.53167	1.54352	(41)
$C_{11}H_{14}O$	3-Isopropenyl-4-methoxytoluene	17.6	0.9661	1.52567	1.53083	1.54450	1.55686	(14)
$C_{11}H_{14}O$	*o*-Propenyl-*p*-methoxytoluene	12.25	0.9856	1.54948	1.55573	1.57349	1.59021	(14)
$C_{11}H_{14}O$	2′, 2′, 5-Trimethyl-2-hydroxystyrene	21.5	0.9912	1.54430	1.55013	1.56502	1.57869	(14)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_{11}H_{14}O$	*sym.-m*-Xylenyl allyl ether	11.6	0.9548	1.51297	1.51793	1.52942	1.54006	(47)
$C_{11}H_{14}O$	*asym.*-Propionyl-*o*-xylene	15.1	0.8749	1.49925	1.50294	1.51375	1.52277	(89)
$C_{11}H_{14}O_2$	*m*-Propio-*p*-methoxytoluene	18.9	1.0484	1.52638	1.53179	1.54650	1.56045	(41)
$C_{11}H_{14}O_2$	*o*-Isobutyro-*o*-cresol	20.4	1.0468	1.53019	1.53663*	1.55395	1.57256	(40)
$C_{11}H_{14}O_2$	*o*-Isobutyro-*m*-cresol	13.3	1.0485	1.53656	1.54308*	1.56091	1.57931	(30)
$C_{11}H_{14}O_2$	*o*-Isobutyro-*p*-cresol	21.3	1.0425	1.52912	1.53550	1.55364	1.57256	(41)
$C_{11}H_{14}O_2$	*p*-Isobutyroanisole	16.6	1.0498	1.53328	1.53925	1.55489	1.56926	(41)
$C_{11}H_{14}O_2$	*o*-Isobutyro-*asym.-m*-xylenol	14	1.0334	1.52910	1.53555*	1.55321	1.57189	(40)
$C_{11}H_{14}O_2$	Methyleugenol	11	1.041	1.5328	1.5373	1.5511	1.5631	(128)
$C_{11}H_{14}O_2$	Methylisoeugenol	11.5	1.064	1.5649	1.5720	1.5911	1.6096	(128)
$C_{11}H_{14}O_2$	*o*-Tolyl isobutyrate	16.6	1.0036	1.48874	1.49262*	1.50222	1.51040	(40)
$C_{11}H_{14}O_2$	Ethyl hydrocinnamate	20	1.0147	1.49150	1.49542	1.50476	1.51277	(92)
$C_{11}H_{14}O_3$	*o*-(α-Hydroxyisobutyro)-*p*-cresol	54.0	1.0943	1.52824	1.53470	1.55342	1.57053	(11)
$C_{11}H_{14}O_3$	*o*-(α-Hydroxypropionyl)-*p*-methoxytoluene	19.2	1.0994	1.52158	1.52630	1.53963		(72)
$C_{11}H_{14}O_3$	Ethyl *o*-toloxyacetate	12.9	1.0848	1.50249	1.50608	1.51669	1.52554	(16)
$C_{11}H_{14}O_3$	Methyl *o*-methoxyhydrocinnamate	18.4	1.0954	1.50848	1.51260	1.52320	1.53246	(16)
$C_{11}H_{14}O_4$	α-Hydroxypropionylhydroquinol dimethyl ether	13.4	1.1486	1.53031	1.53527	1.54999		(72)
$C_{11}H_{14}O_6$	Diethyl succinylmalonate	73.0	1.1675	1.46923	1.47245	1.48170	1.48952	(36)
$C_{11}H_{16}$	*p-tert.*-Butyltoluene	13.25	0.8667	1.49118	1.49465	1.50513	1.51400	(13)
$C_{11}H_{16}$	1, 1-Dimethylpropene-2, 5-cyclohexadiene	15.2	0.8618	1.50189	1.50633	1.51925	1.53040	(89)
$C_{11}H_{16}$	*sym.*-Ethylpseudocumene	12.05	0.8938	1.51078	1.51474	1.52580	1.53481	(89)
$C_{11}H_{16}$	2-Methylcymene	15.5	0.8740	1.49601	1.50001	1.51030	1.51913	(143)
$C_{11}H_{16}$	2-Methylmenthatriene	15	0.8776	1.49803	1.50217	1.51260	1.52188	(143)
$C_{11}H_{16}$	Pentamethylbenzene	72.8	0.8786	1.50104	1.50489	1.51609		(89)
$C_{11}H_{16}$	*asym.*-Propyl-*o*-xylene	12.7	0.8719	1.49504	1.49881	1.50920	1.51784	(89)
$C_{11}H_{16}$	1, 1, 3-Trimethyl-4-ethene-2, 5-cyclohexadiene	12.7	0.8844	1.51470	1.51931	1.53230	1.54371	(89)
$C_{11}H_{16}$	1, 2, 5-Trimethyl-4-ethylbenzene	15.75	0.8867	1.50654	1.51047	1.52163	1.53112	(20)
$C_{11}H_{16}$	1, 3, 5-Trimethyl-2-ethylbenzene	16.35	0.8885	1.50875	1.51274	1.52416	1.53376	(20)
$C_{11}H_{16}$	1, 1, 2, 6-Tetramethyl-4-methene-2, 5-cyclohexadiene	23.2	0.8766	1.50884	1.51350	1.52660	1.53830	(89)
$C_{11}H_{16}$	1, 1, 3, 6-Tetramethyl-4-methene-2, 5-cyclohexadiene	15.2	0.8809	1.51235	1.51687	1.53006	1.54172	(89)
$C_{11}H_{16}Cl_2O$	1-Isopropyl-4-methyl-4-dichloromethyl-1-cyclohexen-3-one	15.8	1.1654	1.51343	1.51769	1.52677	1.53540	(52)
$C_{11}H_{16}Cl_2O$	1-Isopropyl-4-methyl-4-dichloromethyl-5-cyclohexen-3-one	16.8	1.1421	1.49798	1.50142	1.50877	1.51532	(52)
$C_{11}H_{16}O$	Carvacrol methyl ether	23	0.9385	1.50126	1.50518	1.51603	1.52566	(47)
$C_{10}H_{16}O$	Citral	17	0.8897	1.48506	1.48945	1.50073	1.51081	(44)
$C_{10}H_{16}O$	Cyclocitral	13.3	0.9566	1.49341	1.49707	1.50689	1.51575	(44)
$C_{11}H_{16}O$	*o*-Ethyl-*sym.-m*-xylenyl methyl ether	12.8	0.9624	1.51322	1.51811	1.52949	1.53968	(47)
$C_{11}H_{16}O$	Hemimellitenyl ethyl ether	22.8	0.9541	1.51054	1.51461	1.52608	1.53586	(47)
$C_{11}H_{16}O$	Mesityl ethyl ether	13.2	0.9364	1.49489	1.49859	1.50930	1.51834	(47)
$C_{11}H_{16}O$	Pseudocumenyl ethyl ether	14.95	0.9460	1.50705	1.51097	1.52247	1.53224	(47)
$C_{11}H_{16}O$	Thymol methyl ether	28	0.9332	1.49817	1.50240	1.50902	1.51322	(162)
$C_{11}H_{16}O_2$	Ethyl 1-methylcyclohexene-1-methene-3-carboxylate	17.3		1.52646	1.53312	1.55148	1.56940	(45)
$C_{11}H_{16}O_4$	Diethyl crotonylidenemalonate	16.7	1.0483	1.47803	1.48291*	1.49570		(27)
$C_{11}H_{16}O_4$	Diethyl isoprenedicarboxylate	17.0	1.0586	1.49515	1.50081*	1.51560	1.52985	(27)
$C_{11}H_{16}O_6$	Diethyl acetylmalonate *O*-acetate	14.95	1.1161	1.44877	1.45145	1.45925	1.46581	(34)
$C_{11}H_{16}O_6$	Diethyl diacetylmalonate	17.0	0.9712	1.43037	1.43257		1.44255	(34, 105)
$C_{11}H_{16}O_7$	Triethyl oxalylmalonate	16.1	1.1599	1.44666	1.44955	1.45742	1.46432	(35)
$C_{11}H_{16}O_8$	Dimethyldiethyl methanetetracarboxylate	17.2	1.1828	1.43098	1.43327	1.43891	1.44350	(35)
$C_{11}H_{17}NO_2$	Ethyl tropidine-2-carboxylate	11.7	1.0721	1.49615	1.49930	1.50768	1.51462	(25)
$C_{11}H_{17}NO_3$	Ethyl tropinone-2-carboxylate	20.8	1.1207	1.49225	1.49537	1.50432		(25)
$C_{11}H_{17}NO_4$	Diethyl propylcyanomalonate	20	1.0332	1.4269	1.4291	1.4343	1.4388	(138)
$C_{11}H_{18}O_2$	Diosphenol methyl ether	19.2	0.988	1.48405	1.48783*	1.49744	1.50601	(32)
$C_{11}H_{18}O_2$	Ethyl α-cyclohexenepropionate	17.5	0.9683	1.46204	1.46459	1.47149	1.47683	(46)
$C_{11}H_{18}O_2$	Ethyl isolauronolate	17.2	0.95339	1.46307	1.46624	1.47429	1.48127	(43)
$C_{11}H_{18}O_2$	Ethyl hexylpropiolate	11.6	0.9154	1.44965	1.45227	1.4593	1.4648	(150)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_{11}H_{18}O_2$	Ethyl 2-methylcyclohexylidene-1-acetate	14.8	0.9587	1.47524	1.47906	1.48816	1.49639	(46)
$C_{11}H_{18}O_2$	Ethyl 3-methylcyclohexylidene-1-acetate	15.0	0.9571	1.47347	1.47730	1.48622	1.49464	(46)
$C_{11}H_{18}O_2$	Ethyl 4-methylcyclohexylidene-1-acetate	17.0	0.9943	1.47013	1.47378	1.48311	1.49133	(46)
$C_{11}H_{18}O_2$	Ethyl 2-methylcyclohexene-1-acetate	18.4	0.9476	1.45125	1.45393		1.46639	(46)
$C_{11}H_{18}O_2$	Ethyl 3-methylcyclohexene-1-acetate	15.2	0.9506	1.45325	1.45592	1.46236	1.46844	(46)
$C_{11}H_{18}O_2$	Methyl 1, 3-dimethylcyclohexylidene-5-acetate	15.0	0.9569	1.47252	1.47628	1.48477	1.49251	(84)
$C_{11}H_{18}O_2$	Hydroxymethylenementhone	15.5	1.0010	1.49556	1.49997	1.51268	1.52496	(17,† 56)
$C_{11}H_{18}O_2$	Methyl geranate	19.1	0.9220	1.46770	1.47143	1.48106	1.48929	(44)
$C_{11}H_{18}O_4$	Diethyl *cis*-α, β-dimethylglutaconate	20.3	1.0241	1.45039	1.45347*	1.46086	1.46731	(73)
$C_{11}H_{18}O_4$	Diethyl *trans*-α, β-dimethylglutaconate	19.3	1.0320	1.45079	1.45382*	1.46126	1.46771	(73)
$C_{11}H_{18}O_5$	Diethyl acetylethylmalonate	19.25	1.0542	1.43185	1.43382	1.43971	1.44440	(34,† 105)
$C_{11}H_{18}O_5$	Diethyl *n*-butyrylmalonate	22	1.0530	1.44113	1.44421	1.45132	1.45765	(56)
$C_{11}H_{18}O_5$	Diethyl isobutyrylmalonate	19.0	1.0514	1.43801	1.44079	1.44786	1.45395	(56)
$C_{11}H_{18}O_5$	Ethyl α-ethyl-β-hydroxycarbethoxy-α, β-crotonate	18	1.0579	1.44127	1.44396		1.45621	(43,† 105)
$C_{11}H_{19}NO$	Camphoroxime methyl ether	22.5	0.9578	1.47665	1.47949	1.48639	1.49216	(106)
$C_{11}H_{19}NO_2$	Propionyltropein	19.6	1.0399	1.47208	1.47434	1.48069	1.48591	(25)
$C_{11}H_{19}NO_2$	Ethyl tropane-2-carboxylate	20.5	1.0408	1.47272	1.47562	1.48197	1.48719	(25)
$C_{11}H_{20}O$	Bornyl methyl ether	23.4	0.9135	1.45992	1.46237	1.46838	1.47329	(97)
$C_{11}H_{20}O$	2, 6-Dimethyl-2, 8-nonadien-6-ol	16.6	0.8661	1.46154	1.46469	1.47208	1.47850	(71)
$C_{11}H_{20}O$	5-Ethyl-1, 8-nonadien-5-ol	20.7	0.8660	1.45945	1.46231	1.46942	1.47537	(71)
$C_{11}H_{20}O_2$	Ethyl α, β-nonenate	19	0.8901	1.43972	1.44263*	1.44946	1.45544	(69)
$C_{11}H_{20}O_4$	Diethyl diethylmalonate	16.6	0.9880	1.42308	1.42516	1.43044	1.43492	(9)
$C_{11}H_{20}O_4$	Diethyl *fum.-sym.*-dimethylglutarate	15.9	0.9807	1.42185	1.42402*	1.42912	1.43346	(73)
$C_{11}H_{20}O_4$	Diethyl *mal.-sym.*-dimethylglutarate	17.0	0.9824	1.42195	1.42419	1.42917	1.43342	(73)
$C_{11}H_{20}O_4$	Diethyl trimethylsuccinate	16.7	0.9956	1.42659	1.42891*	1.43402	1.43840	(73)
$C_{11}H_{21}N$	*N*-Methylcamphidine	19.0	0.9011	1.47378	1.47625	1.48308	1.48869	(25)
$C_{11}H_{22}N_2$	Diisoamylcyanamide	23.7	0.8461	1.43691	1.43915		1.44938	(106)
$C_{11}H_{22}O$	Methyl nonyl ketone	17.3	0.8295	1.42765	1.43002	1.43539	1.44099	(125)
$C_{11}H_{22}O_2$	*n*-Decyl formate	20	0.8732	1.42484	1.42707	1.43217	1.43648	(163)
$C_{11}H_{24}O$	Methyl *n*-decyl ether	20	0.7973	1.41952	1.42177	1.42696	1.43126	(163)
$C_{12}H_8O$	Diphenylene oxide	99.3	1.0886	1.59964	1.60794	1.63272	1.65367	(48)
$C_{12}H_{10}$	Acenaphthene	99.2	1.0242	1.59877	1.60658	1.62838		(48)
$C_{12}H_{10}$	Diphenyl	77.1	0.9896	1.58112	1.58822	1.60760	1.62538	(48)
$C_{12}H_{10}O$	4-Methyl-1-naphthaldehyde	38.2	1.1252	1.63548	1.64567	1.67575	1.70698	(145)
$C_{12}H_{10}O$	Methyl α-naphthyl ketone	21.5	1.1171	1.61926	1.62796	1.65273	1.67686	(145)
$C_{12}H_{10}O_2$	4-Methoxy-1-naphthaldehyde	43.7	1.1829	1.64151	1.65299	1.68748		(48)
$C_{12}H_{12}$	1, 2-Dimethylnaphthalene	16.35	1.0219	1.61014	1.61795	1.63945	1.65976	(48)
$C_{12}H_{12}$	1, 6-Dimethylnaphthalene	16.3	1.0049	1.60119	1.60886	1.63021	1.64958	(48)
$C_{12}H_{12}$	Isobutylenephenylacetylene	13	0.9301	1.57675	1.58281	1.6046	1.61954	(150)
$C_{12}H_{12}N_2O$	2-Allylacetylindazole (stable)	22.6	1.1172	1.56427	1.57070*	1.58716	1.60470	(33)
$C_{12}H_{12}O$	α-Ethoxynaphthalene	15.7	1.0643	1.59600	1.60351	1.62501	1.64508	(48,† 161)
$C_{12}H_{12}O$	β-Ethoxynaphthalene	47.3	1.0413	1.58602	1.59324	1.61409	1.63312	(48,† 161)
$C_{12}H_{12}O_2$	Ethyl indene-β-carboxylate	73.9	1.0544	1.54126	1.54809	1.56773		(16)
$C_{12}H_{12}O_3$	1, 4-Dimethyl-2-acetoxycoumarone	15.7	1.1361	1.53580	1.54080	1.55571	1.56884	(23)
$C_{12}H_{12}O_3$	Ethyl 2-methylcoumarilate	56.6	1.1164	1.54133	1.54817	1.56657	1.58330	(41)
$C_{12}H_{12}O_3$	Ethyl 5-methylcoumarilate	43.9	1.1187	1.54821	1.55575	1.57565	1.59513	(41)
$C_{12}H_{12}O_4$	Ethyl benzoylformylacetate	24.9	1.1400	1.52561	1.53134	1.54631	1.55981	(105)
$C_{12}H_{12}O_4$	Ethyl 2-methoxycoumarilate	70	1.1595	1.54280	1.54987	1.59611		(41)
$C_{12}H_{12}O_4$	Ethyl 1-methylcoumaran-2-one-1-carboxylate	16.7	1.1919	1.53316	1.53902	1.55541	1.57176	(19)
$C_{12}H_{12}S$	α-(*o*-Methylbenzyl)-thiophene	12.1	1.0908	1.58392	1.58969*	1.60416	1.61692	(59)
$C_{12}H_{13}ClO_2$	Ethyl β-chloro-α (*p*-tolyl)-acrylate	19.7	1.1363	1.53053	1.53579	1.54962	1.56029	(3)
$C_{12}H_{13}N$	Dimethyl-α-naphthylamine	10.8	1.04694	1.61787	1.62609	1.65158	1.67629	(161)
$C_{12}H_{13}N$	Dimethyl-β-naphthylamine	53.2		1.63291	1.64432	1.67682	1.71289	(161)
$C_{12}H_{13}N$	α-Ethylaminonaphthalene	15.1	1.0652	1.63758	1.64773	1.67799	1.71062	(145)
$C_{12}H_{13}N$	β-Ethylaminonaphthalene	21.3	1.0545	1.64389	1.65440	1.68469	1.71642	(145)
$C_{12}H_{14}$	1-Phenyl-1-cyclohexene	14.2	0.9905	1.56612	1.57157	1.58679	1.60026	(83)
$C_{12}H_{14}$	1-Phenyl-1, 3-hexadiene	12	0.9253	1.59164	1.60252	1.62999	1.65874	(45,† 142)
$C_{12}H_{14}Cl_2O_2$	Ethyl 1-methyl-1-dichloromethyl-2, 5-cyclohexadiene-4-methenecarboxylate	22.1	1.2150	1.56171	1.56911	1.58984		(3)
$C_{12}H_{14}Cl_2O_2$	Ethyl β, β-dichloro-α(*p*-tolyl)-propionate	18.7	1.2017	1.51729	1.52137	1.53173	1.54070	(3)
$C_{12}H_{14}N_2$	1-Benzyl-3, 5-dimethylpyrazole	15.0	1.0383	1.54628	1.55113*	1.56292	1.57312	(60)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_{12}H_{14}N_2$	1-Phenyl-3, 4, 5-trimethylpyrazole	18.7	1.0453	1.56543	1.57152*	1.58685	1.60080	(60)
$C_{12}H_{14}N_2O$	2-Isovalerylindazole (stable)	16.3	1.0879	1.54870	1.55466*	1.57012	1.58451	(33)
$C_{12}H_{14}N_2O_2$	Ethyl 1-ethylindazole-3-carboxylate	17.3	1.1431	1.55924	1.56587*	1.58318	1.59991	(29)
$C_{12}H_{14}N_2O_2$	Ethyl 2-ethylindazole-3-carboxylate	22.8	1.1289	1.56355	1.57123*	1.59221	1.61255	(29)
$C_{12}H_{14}O$	*o*, *o*-Diallylphenol	15.4	0.9918	1.53676	1.54163	1.55480	1.56579	(47)
$C_{12}H_{14}O$	α-Benzalmethyl propyl ketone	17.5	0.9978	1.56235	1.57046	1.59316	1.61594	(8)
$C_{12}H_{14}O$	α-Benzalmethyl isopropyl ketone	24.6	0.9858	1.55870	1.56693	1.59000	1.61338	(8)
$C_{12}H_{14}O$	5, 7-Dimethyl-1-ketotetrahydronaphthalene	15.5	1.0654	1.55986	1.56496	1.57971	1.59284	(146)
$C_{12}H_{14}O$	7-Ethyl-1-ketotetrahydronaphthalene	17.2	1.0556	1.55478	1.55988	1.57454	1.58752	(146)
$C_{12}H_{14}O$	*o*-Allylphenyl allyl ether	15.0	0.9676	1.52188	1.52634	1.53900	1.54981	(47)
$C_{12}H_{14}O$	1, 4-Dimethyl-2-ethylcoumarone	11.4	1.0108	1.54187	1.54715	1.56233	1.57583	(23)
$C_{12}H_{14}O$	2, 4, 6-Trimethyl-α-chromene	14.25	1.0172	1.54841	1.55389	1.56984	1.58443	(23)
$C_{12}H_{14}O$	3, 4, 6-Trimethyl-α-chromene	15.2	1.0336	1.55407	1.55968	1.57565		(23)
$C_{12}H_{14}O_2$	Butyrylacetophenone	21.0	1.0478	1.56208	1.57075	1.59629	1.62394	(56)
$C_{12}H_{14}O_2$	Diethylphthalide	61.6	1.0403	1.50385	1.50872	1.51905		(49)
$C_{12}H_{14}O_2$	1, 4-Dimethyl-1-ethylcoumaranone	19.6	1.0559	1.53023	1.53604	1.55356	1.57169	(19)
$C_{12}H_{14}O_2$	1-Ethyl-3, 5-dimethylcoumaranone	20.5	1.0667	1.53689	1.54240	1.55907	1.57403	(66)
$C_{12}H_{14}O_2$	1-Isopropyl-4-methylcoumaranone	13.8	1.0707	1.53692	1.54286	1.56046	1.57857	(19)
$C_{12}H_{14}O_2$	5-Methyl-2-*n*-propylcoumaranone	16.8	1.0675	1.53967	1.54589	1.56268	1.58066	(85)
$C_{12}H_{14}O_2$	1, 1, 3, 5-Tetramethylcoumaranone	18.2	1.0620	1.53765	1.54359	1.56110	1.57820	(66)
$C_{12}H_{14}O_2$	Ethyl α-methylcinnamate	20.6	1.0321	1.54074	1.54753	1.56500	1.58162	(45)
$C_{12}H_{14}O_2$	Ethyl β-methylcinnamate	16.6	1.0392	1.53930	1.54558	1.56165	1.57654	(14, 45†)
$C_{12}H_{14}O_2$	Ethyl *o*-methylcinnamate	16.3	1.0428	1.54852	1.55552	1.57593	1.59533(?)	(14)
$C_{12}H_{14}O_2$	Ethyl *p*-methylcinnamate	15.9	1.0340	1.55503	1.56302	1.58531	1.60748	(8,† 14)
$C_{12}H_{14}O_2$	Methyl α, *p*-dimethylcinnamate	18.3	1.0507	1.55635	1.56400	1.58432	1.60362	(14)
$C_{12}H_{14}O_2$	Methyl β, *p*-dimethylcinnamate	60.2	1.0144	1.53389	1.54084	1.55926		(14)
$C_{12}H_{14}O_3$	5-Methyl-2-methoxybenzoylacetone	17.9	1.1196	1.57582	1.58562	1.61562		(66)
$C_{12}H_{14}O_3$	1, 4-Dimethyl-1-ethoxycoumaranone	14.05	1.1030	1.52654	1.53217	1.54976	1.56849	(12, 19†)
$C_{12}H_{14}O_3$	Methyl *p*-tolyldiketone ethyl ether	65.0	1.0524	1.50733	1.51270	1.52888		(18)
$C_{12}H_{14}O_3$	Ethyl β-phenylmethylglycidate	16.7	1.0936	1.50197	1.50603	1.51569		(16)
$C_{12}H_{14}O_3$	Ethyl 1-methylcoumarane-4-carboxylate	14.3	1.1179	1.53045	1.53626	1.55037	1.56357	(16)
$C_{12}H_{14}O_3$	Ethyl *p*-methoxycinnamate	59.2	1.0664	1.55317	1.56193	1.58829		(14)
$C_{12}H_{14}O_3$	Methyl allo-β-methyl-*o*-methoxycinnamate	17.0	1.0978	1.53346	1.53897	1.55282	1.56547	(14)
$C_{12}H_{14}O_3$	Methyl α-methyl-*o*-methoxycinnamate	15.2	1.1261	1.56466	1.57207	1.59347		(14)
$C_{12}H_{14}O_3$	Methyl β-methyl-*o*-methoxycinnamate	16.65	1.1037	1.54267	1.54881	1.56490	1.57991	(14)
$C_{12}H_{14}O_4$	Apiol	14	1.176	1.5330	1.5380	1.5510	1.5619	(128)
$C_{12}H_{14}O_4$	Isapiol	12	1.197	1.5639	1.5703	1.5892	1.6062	(128)
$C_{12}H_{14}O_4$	Diethyl phthalate	17.7	1.1203	1.49890	1.50293	1.51356	1.52284	(80,† 104, 145)
$C_{12}H_{14}O_4$	Diethyl isophthalate	17.5	1.1232	1.50361	1.50815	1.51938		(80)
$C_{12}H_{16}$	β, β-Diethylstyrene	18.7	0.8924	1.51199	1.51677	1.52837	1.53866	(43)
$C_{12}H_{16}$	*ar.*-1, 3-Dimethyltetrahydronaphthalene	21.0	0.9589	1.53683	1.54094	1.55287	1.56297	(146)
$C_{12}H_{16}$	*ar.*-2-Ethyltetrahydronaphthalene	17.6	0.9499	1.53072	1.53474	1.54627	1.55594	(146)
$C_{12}H_{16}$	α-Ethyl-β, β-dimethylstyrene	17.5	0.8886	1.50950	1.51422	1.52569	1.53575	(43)
$C_{12}H_{16}N_2$	1-Isoamylindazole	16.3	1.0047	1.54160	1.54724	1.56138	1.57470	(60)
$C_{12}H_{16}N_2$	2-Isoamylindazole	18.5	1.0084	1.55248	1.55877*	1.57452	1.58954	(60)
$C_{12}H_{16}N_2$	Propylpropenyl-*o*-phenylenediamine	20.8	1.0341	1.55712	1.56255	1.57687	1.58971	(109)
$C_{12}H_{16}O$	*o*-Allyl-*sym.*-*m*-xylenyl allyl ether	12.8	0.9666	1.52228	1.52750	1.53938	1.55029	(47)
$C_{12}H_{16}O$	2′, 2′, 5-Trimethyl-2-hydroxystyrene methyl ether	17.05	0.9679	1.53681	1.54253	1.55778	1.57181	(14)
$C_{12}H_{16}O_2$	*o*-Isovalero-*p*-cresol	18.4	1.0291	1.52683	1.53270	1.55001	1.56848	(65)
$C_{12}H_{16}O_2$	*o*-Isobutyro-*p*-methoxytoluene	13.7	1.0240	1.51685	1.52175	1.53545	1.54811	(41)
$C_{12}H_{16}O_2$	Ethyleugenol	9.5	1.021	1.5256	1.5301	1.5426	1.5529	(128)
$C_{12}H_{16}O_2$	Ethylisoeugenol	11	1.044	1.5540	1.5607	1.5792	1.5993	(128)
$C_{12}H_{16}O_2$	Ethylchavibetol	11.5	1.013	1.5232	1.5276	1.5403	1.5514	(128)
$C_{12}H_{16}O_2$	Ethylisochavibetol	11	1.039	1.5539	1.5602	1.5792	1.5980	(128)
$C_{12}H_{16}O_2$	Amyl benzoate	17.4	0.9910	1.49114	1.49498	1.50530	1.51420	(145)
$C_{12}H_{16}O_2$	Ethyl γ-phenylbutyrate	19.45	1.0015	1.49028	1.49396	1.50317	1.51110	(70)
$C_{12}H_{16}O_3$	Asaron	11	1.091	1.5648	1.5719	1.5931	1.6142	(128)
$C_{12}H_{16}O_3$	Ethyl 3-methyl-4-ethoxybenzoate	15.1	1.0618	1.51443	1.51908	1.53259	1.54428	(16)
$C_{12}H_{18}$	2-Ethylcymene	15.6	0.8708	1.49494	1.49878	1.50878	1.51739	(143)
$C_{12}H_{18}$	2-Ethylmenthatriene	15	0.8880	1.50429	1.50847	1.51920	1.52763	(143)
$C_{12}H_{18}$	1, 1, 3, 6-Tetramethyl-4-ethene-2, 5-cyclohexadiene	15.4	0.8837	1.51028	1.51452	1.52702	1.53796	(89)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_{12}H_{18}N_2O_2$	2-Carbethoxy-7-methyltetrahydroindazole	21.8	1.0911	1.50218	1.50555*	1.51363	1.52027	(60)
$C_{12}H_{18}O_2$	Acetylcamphor	17.9	1.0314	1.49077	1.49415	1.50284	1.51057	(119)
$C_{12}H_{18}O_2$	Methoxymethylenecamphor	15.2	1.0234	1.50524	1.50913	1.51997	1.52986	(17)
$C_{12}H_{18}O_2$	Methylformylcamphor	23.1	1.0214	1.50118	1.50513		1.52376	(105)
$C_{12}H_{18}O_2$	Ethyl 1, 5-dimethylcyclohexene-1-methene-3-carboxylate	20.6	0.9701	1.51237	1.51848	1.53424	1.54950	(45)
$C_{12}H_{18}O_3$	Diosphenol acetate	14.6	1.0415	1.48027	1.48378*	1.49233	1.49996	(32)
$C_{12}H_{18}O_3$	Ethyl diallylacetoacetate	17.4	0.9823	1.45426	1.45716		1.47001	(105)
$C_{12}H_{18}O_3$	Ethyl isophoronecarboxylate	20.4	1.0291	1.47539	1.47878	1.48732	1.49738	(43,† 44)
$C_{12}H_{18}O_3$	Methyl camphocarboxylate	18.0	1.0847	1.48080	1.48333	1.48945	1.49461	(113,† 122)
$C_{12}H_{18}O_4$	Dimethyl *d*-dehydrocamphorate	18.1	1.0881	1.47078	1.47363	1.48096	1.48724	(9)
$C_{12}H_{18}O_4$	Dimethyl isodehydrocamphorate	17.5	1.0851	1.46526	1.46782	1.47434	1.47988	(9)
$C_{12}H_{18}O_6$	Diethyl propionylmalonate *O*-acetate	16.7	1.0983	1.44937	1.45211	1.45972	1.46611	(34)
$C_{12}H_{18}O_6$	Diethyl acetylmalonate *O*-propionate	18.6	1.0984	1.44918	1.45191	1.45967	1.46627	(34)
$C_{12}H_{18}O_6$	Triethyl aconitate	20	1.1064	1.45255	1.45562	1.46325	1.46981	(45,† 95)
$C_{12}H_{18}O_7$	Diethyl *O*-carbethoxy-*β*-hydroxyethylidenemalonate	15.1	1.1322	1.44787	1.45059	1.45802	1.46436	(35)
$C_{12}H_{18}O_7$	Triethyl acetylmethanetricarboxylate	13.5	1.1283	1.43456	1.43658	1.44257	1.44722	(35)
$C_{12}H_{20}O$	Ethylcamphor	24.3	0.9340	1.46624	1.46864	1.47453	1.47938	(97)
$C_{12}H_{20}O_2$	1, 1, 3, 3-Tetraethyl-2, 4-diketocyclobutane	17.75	0.9456	1.44962	1.45181	1.45803	1.46295	(18)
$C_{12}H_{20}O_2$	Diosphenol ethyl ether	19.0		1.48405	1.48788*	1.49743	1.50601	(32)
$C_{12}H_{20}O_2$	Bornyl acetate	22.6	0.9833	1.45998	1.46225	1.46827	1.47319	(25)
$C_{12}H_{20}O_2$	Isobornyl acetate	23.4	0.9807	1.45978	1.46191	1.46798	1.47275	(25)
$C_{12}H_{20}O_2$	Ethyl 1, 3-dimethyl-4-cyclohexene-5-acetate	13.8	0.9455	1.45901	1.46178	1.46869	1.47458	(84)
$C_{12}H_{20}O_2$	Ethyl 1, 3-dimethylcyclohexylidene-5-acetate	20.3	0.9374	1.45481	1.45753	1.46416	1.46965	(84)
$C_{12}H_{20}O_3$	Ethyl 1, 3-dimethyl-3-cyclohexene-5-hydroxy-5-acetate	17.6		1.46857	1.47133	1.47829	1.48411	(76)
$C_{12}H_{20}O_4$	Diethyl *cis*-*β*-methyl-*α*-ethylglutaconate.	20.9	1.0182	1.45168	1.45487*	1.46256	1.46929	(73)
$C_{12}H_{20}O_4$	Diethyl *trans*-*β*-methyl-*α*-ethylglutaconate	19.9	1.0143	1.44984	1.45292*	1.46017	1.46658	(73)
$C_{12}H_{20}O_4$	Diethyl *cis*-hexahydrophthalate	16.8	1.0570	1.45207	1.45451	1.45992	1.46460	(73)
$C_{12}H_{20}O_4$	Diethyl *trans*-hexahydrophthalate	14.4	1.0449	1.44996	1.45235*	1.45791	1.46268	(73)
$C_{12}H_{20}O_4$	Diethyl *cis*-hexahydroisophthalate	14.1	1.0505	1.45176	1.45414*	1.45970	1.46431	(73)
$C_{12}H_{20}O_4$	Diethyl *cis*-hexahydroterephthalate	20.6	1.0516	1.44978	1.45222*	1.45769	1.46237	(73)
$C_{12}H_{20}O_4$	Dimethyl camphorate	16.9	1.0774	1.46098	1.46334		1.47366	(99)
$C_{12}H_{20}O_4$	Ethyl acid camphorate	16.8	1.10235	1.47126	1.47372	1.47955	1.48431	(97)
$C_{12}H_{20}O_5$	Diethyl isovalerylmalonate	21.0	1.0331	1.44138	1.44429	1.45156	1.45793	(56)
$C_{12}H_{20}O_7$	Triethyl citrate	20	1.1369	1.44302	1.44554	1.45133	1.45609	(93)
$C_{12}H_{21}NO$	Camphoroxime ethyl ether	17.0	0.9473	1.47574	1.47853		1.49122	(106)
$C_{12}H_{22}N_2$	*γ*-Ethylenedipiperidine	17.8	0.9212	1.48570	1.48869	1.49603	1.50219	(106)
$C_{12}H_{22}O$	1, 1-Dimethyl-4, 4-diethyl-cyclohexan-2-one	15.2	0.9112	1.46086	1.46307	1.46914	1.47419	(68)
$C_{12}H_{22}O$	Bornyl ethyl ether	24.7	0.8969	1.45329	1.45554	1.46131	1.46591	(97)
$C_{12}H_{22}O_2$	Amylpropiolic acetal	9.5	0.8858	1.43980	1.44210	1.4483	1.45307	(150)
$C_{12}H_{22}O_2$	Ethyl 2-methyl-5-isopropylcyclopentane-1-carboxylate	11.8	0.9178	1.44047		1.44825	1.45272	(130)
$C_{12}H_{22}O_3$	Ethyl *β*-amyl-*β*-ethoxyacrylate	23.2	0.9307	1.44865	1.45179	1.45996	1.46716	(17)
$C_{12}H_{22}O_3$	Ethyl 1, 3-dimethylcyclohexan-5-ol-5-acetate	14.9	0.9895	1.45442	1.45664	1.46269	1.46777	(84)
$C_{12}H_{22}O_4$	Bis-diethylacetal	26	0.9529	1.4289	1.43276	1.4386	1.4432	(150)
$C_{12}H_{22}O_4$	Diethyl tetramethylsuccinate	22.7	0.9928	1.43246	1.43484*	1.44001	1.44450	(73)
$C_{12}H_{23}NO_2$	Ethyl *cis*-*p*-amino-*o*, *o*, *o*′-trimethylhexahydrobenzoate	21.1	0.9888	1.47188	1.47493*	1.48167	1.48776	(73)
$C_{12}H_{23}NO_2$	Ethyl *trans*-*p*-amino-*o*, *o*, *o*′-trimethylhexahydrobenzoate	21.1	0.9789	1.46938	1.47219*	1.47823	1.48356	(73)
$C_{12}H_{24}N_2O_4$	Diethylhydrazoisobutyrate	20.5	0.9985	1.43165	1.43403*	1.43941	1.44411	(29)
$C_{12}H_{24}O$	1, 1-Dimethyl-4, 4-diethylcyclohexan-2-ol	13.6	0.9196	1.47367	1.47588	1.48213	1.48715	(68)
$C_{12}H_{24}O$	Menthyl ethyl ether	17.1	0.8535	1.44125	1.44347	1.44897	1.45358	(97)
$C_{12}H_{24}O_2$	*n*-Decyl acetate	20	0.8671	1.42494	1.42727	1.43257	1.43698	(163)
$C_{12}H_{26}O$	Ethyl *n*-decyl ether	20	0.7942	1.42032	1.42227	1.42753	1.43173	(163)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_{12}H_{27}N$	Triisobutylamine	17.3	0.7711	1.42280	1.42519		1.43571	(106)
$C_{12}H_{27}N_3$	Triformalpropylamine	18.8	0.8795	1.45712	1.45974	1.46630	1.47171	(109)
$C_{13}H_{10}O$	Benzophenone:							
	(Stable)	45.2	1.0889	1.58932	1.59750	1.61615		(45)
	(Labile)	23.4	1.1076	1.59836	1.60596	1.62519	1.64190	(45)
$C_{13}H_{12}$	Diphenylmethane	20	1.0060	1.57145	1.57683	1.59183	1.60483	(48)
$C_{13}H_{12}O$	1-Methyl-2-acetylnaphthalene	16.1	1.1046	1.61816	1.62695	1.65215	1.67720	(145)
$C_{13}H_{12}O$	2-Methyl-(5)8-acetylnaphthalene	13.3	1.0985	1.61572	1.62443	1.64933	1.67405	(145)
$C_{13}H_{12}O_2$	Ethyl 1-naphthoate	14.7	1.1270	1.58914	1.59660	1.61774	1.63770	(48, 161)
$C_{13}H_{12}O_2$	Ethyl 2-naphthoate	22.7	1.1143	1.58756	1.59513	1.61649	1.63543	(48)
$C_{13}H_{12}O_2$	Methyl 6-methyl-1-naphthoate	15.3	1.1400	1.60027	1.60813	1.63056		(48)
$C_{13}H_{13}N$	Benzylaniline	24.8	1.0619	1.5974	1.6118	1.6301	1.6663(?)	(132)
$C_{13}H_{13}N$	Methyldiphenylamine	24.6	1.0466	1.5998	1.6166	1.6391	1.6774	(132)
$C_{13}H_{14}$	1-Methyl-2-ethylnaphthalene	15.4	1.0014	1.59422	1.60138	1.62151	1.63995	(145)
$C_{13}H_{14}$	1-Methyl-4-ethylnaphthalene	13.1	1.0086	1.59839	1.60571	1.62624	1.64490	(145)
$C_{13}H_{14}N_2$	1-Phenyltetrahydroindazole	99.9	1.0608	1.56243	1.56821*	1.58313	1.59647	(60)
$C_{13}H_{14}N_2$	2-Phenyltetrahydroindazole	99.6	1.0544	1.57181	1.57840*	1.59640	1.61353	(60)
$C_{13}H_{14}O$	1-Benzyl-5-cyclohexen-2-one	21.65	1.0612	1.55746	1.56277	1.57641	1.58865	(83)
$C_{13}H_{14}O_2$	2, 2-Diethylindanedione	14.5	1.0693	1.53658	1.54174	1.55632	1.56967	(36)
$C_{13}H_{14}O_2$	Ethyl allocinnamylideneacetate	18.5	1.0445	1.60619	1.61925*	1.65711	1.70021	(27)
$C_{13}H_{14}O_2$	Ethyl cinnamylideneacetate	42.2	1.0294	1.60039	1.61348*	1.65080	1.69311	(27)
$C_{13}H_{14}O_2$	Ethyl *γ*-methylindene-*β*-carboxylate	39.1	1.0740	1.55417	1.56087	1.58022	1.59885	(16)
$C_{13}H_{14}O_2$	Ethyl Δ^1-dihydro-*β*-naphthoate	18	1.0950	1.57134	1.57919	1.60038	1.62169	(70)
$C_{13}H_{14}O_2$	Ethyl Δ^2-dihydro-*α*-naphthoate (labile)	19.6	1.0897	1.53057	1.53486*	1.54549	1.55458	(70)
$C_{13}H_{14}O_2$	Ethyl Δ^1-dihydro-*α*-naphthoate (stable)	20.2	1.1019	1.55326	1.55896*	1.57328	1.58642	(70)
$C_{13}H_{14}O_2$	Ethyl Δ^3-dihydro-*β*-naphthoate	18.2	1.0865	1.54587	1.55133	1.56534	1.57811	(70)
$C_{13}H_{14}O_3$	Ethyl 2, 4-dimethylcoumarilate	59	1.0931	1.53939	1.54642	1.56425	1.58147	(41)
$C_{13}H_{14}O_3$	1-Ethyl-4-methyl-2-acetoxycoumarone	18.7	1.1079	1.52993	1.53493	1.54952	1.56293	(23)
$C_{13}H_{14}O_4$	Ethyl 1, 4-dimethylcoumaran-2-one-1-carboxylate	24.1	1.1533	1.52752	1.53340	1.55002	1.56719	(19)
$C_{13}H_{14}O_4$	Ethyl 1-ethylcoumaran-2-one-1-carboxylate	18.6	1.1548	1.53082	1.53660	1.55289	1.56878	(19)
$C_{13}H_{14}O_4$	Ethyl 2-ethoxycoumarilate	14.3	1.1681	1.55231	1.55922	1.57818	1.59662	(41)
$C_{13}H_{14}O_4$	Ethyl 4-methyl-2-methoxycoumarilate	23.8	1.1701	1.55570	1.56279	1.58240	1.60172	(41)
$C_{13}H_{15}BrO_2$	*o*-(*α*-Bromoisobutyro)-*p*-acetotoluene	25.7	1.3173	1.52435	1.52883	1.54054		(11)
$C_{13}H_{16}$	1-Benzyl-1-cyclohexene	14.1	0.9692	1.54009	1.54426	1.55601	1.56577	(83)
$C_{13}H_{16}$	1-Phenyl-5-methyl-1, 3-hexadiene	20	0.9248	1.57822	1.58727	1.61401	1.64065	(45,† 142)
$C_{13}H_{16}N_2O_2$	Isoamyl indazole-2-carboxylate	15.1	1.1101	1.53715	1.54251*	1.55586	1.56805	(29)
$C_{13}H_{16}O$	*α*-Benzalmethyl *n*-butyl ketone	44.7	0.9596	1.54416	1.55181	1.57293		(8)
$C_{13}H_{16}O$	1, 3-Dimethyl-6-isopropylcoumarone	14.15	0.9993	1.53749	1.54273	1.55724	1.57032	(23)
$C_{13}H_{16}O$	1-Methyl-4-*tert.*-butylcoumarone	13.85	0.9938	1.53326	1.53831	1.55213	1.56460	(23)
$C_{13}H_{16}O_2$	*p*-Tolyl *α*-ethylcrotonate	14.6	1.0134	1.51112	1.51566*	1.52680	1.53675	(30)
$C_{13}H_{16}O_2$	2, 2-Diethyl-5-methylcoumaranone	22.6	1.0320	1.52549	1.53141*	1.54797	1.56575	(30)
$C_{13}H_{16}O_2$	1-Isopropyl-3, 5-dimethylcoumaranone	21	1.0472	1.53396	1.53955	1.55610	1.57256	(66)
$C_{13}H_{16}O_2$	2, 6-Dimethyl-3-ethylchromanone	21.0	1.0627	1.53330	1.53912*	1.55386	1.56988	(30)
$C_{13}H_{16}O_2$	3, 4-Dimethyl-2-ethyl-7-oxyhydrindone	12.2	1.0806	1.54590	1.55190*	1.56733	1.58263	(30)
$C_{13}H_{16}O_2$	Ethyl *α*, *β*-dimethylcinnamate	15.2	1.0202	1.51620	1.52119	1.51903		(14)
$C_{13}H_{16}O_2$	Ethyl *α*-ethylcinnamate	13.75	1.0247	1.53613	1.54252	1.55907	1.57473	(14)
$C_{13}H_{16}O_2$	Isovalerylacetophenone	20.1	1.0307	1.55232	1.56044	1.58492	1.61114	(56)
$C_{13}H_{16}O_2$	Phenylpropiolic acetal	13	0.9940	1.51725	1.52216	1.53373	1.54352	(150)
$C_{13}H_{16}O_3$	Ethyl *β*-ethoxycinnamate	24.5	1.0593	1.52511	1.53072	1.54557	1.55949	(14)
$C_{13}H_{16}O_3$	Ethyl ethylbenzoylacetate	13.7	1.0717	1.50663	1.51103	1.52221	1.53222	(17,† 56)
$C_{13}H_{16}O_3$	Ethyl *α*-methyl-*p*-methoxycinnamate	15.6	1.0894	1.56213	1.57009	1.59339		(37)
$C_{13}H_{16}O_3$	Methyl *α*, *m*-dimethyl-*o*-methoxycinnamate	14.6	1.0989	1.55727	1.56424	1.58477		(14)
$C_{13}H_{16}O_3$	Methyl *β*-methyl-2-methoxy-5-methylcinnamate	12.7	1.0872	1.54083	1.54716	1.56290	1.57804	(14)
$C_{13}H_{16}O_3$	*o*-Isobutyro-*o*-tolyl acetate	18.4	1.0755	1.50985	1.51436*	1.52583	1.53613	(40)
$C_{13}H_{17}NO$	*α*-Mesityloxide oxime benzyl ether	14	0.9919	1.53035	1.53557*	1.54824	1.55961	(74)
$C_{13}H_{17}NO_2$	Ethyl *β*-benzylaminoacetoacetate	21.6	1.0596	1.55119	1.55786	1.57546	1.59273	(109)
$C_{13}H_{18}O$	Thymol allyl ether	15.4	0.9390	1.50622	1.51025	1.52152	1.53110	(47)
$C_{13}H_{18}O$	*o*-Allylthymol	15.4	0.9700	1.52382	1.52809	1.53986	1.54992	(47)
$C_{13}H_{18}O_3$	Ethyl *α*, *p*-toloxyisobutyrate	19.55	1.0270	1.48624	1.48945	1.49916	1.50720	(82)
$C_{13}H_{18}O_3$	*α*-Hydroxydiethylaceto-*p*-cresol	21.1	1.0796	1.53392	1.54040*	1.55820	1.57750	(30)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_{13}H_{20}$	2-Propylcymene	15	0.8685	1.49198	1.49585	1.50549	1.51386	(143)
$C_{13}H_{20}$	2-Propyl-$\Delta^{2,5,8,(9)}$-menthatriene	15	0.8804	1.49900	1.50273	1.51312	1.52141	(143)
$C_{13}H_{20}O$	α-Ionone	22.3	0.9298	1.49452	1.49842	1.50834	1.51735	(44)
$C_{13}H_{20}O$	β-Ionone	18.9	0.9445	1.51443	1.51977	1.53396	1.54783	(45)
$C_{13}H_{20}O$	*o, o*-Diethyl-*sym.*-*m*-xylenyl methyl ether	14.4	0.9507	1.51035	1.51525	1.52546	1.53491	(47)
$C_{13}H_{20}O_2$	Ethylformylcamphor	17.9	1.0036	1.50062	1.50465	1.51592	1.52473	(105)
$C_{13}H_{20}O_2$	Propionylcamphor	18.1	1.0187	1.48729	1.49051	1.49857	1.50569	(119)
$C_{13}H_{20}O_2$	Ethyl bornylenecarboxylate	19.8	0.9828	1.47284	1.47604	1.48332	1.48969	(9)
$C_{13}H_{20}O_2$	Ethyl 1-methyl-4-isopropyl-1, 3-cyclohexadiene-3-carboxylate	16.9	0.9773	1.49592	1.50010	1.51100	1.52074	(54)
$C_{13}H_{20}O_3$	Acetoxymethylenementhone	16.0	1.0318	1.48415	1.48754	1.49697	1.50520	(17)
$C_{13}H_{20}O_3$	Ethyl camphorcarboxylate	24.3	1.0528	1.47106	1.47356	1.47962	1.48454	(97, 113)
$C_{13}H_{20}O_3$	Ethyl methylisophoronecarboxylate	19	1.0248	1.47760	1.48181	1.49023	1.49776	(44)
$C_{13}H_{20}O_4$	Diethyl diallylmalonate	15.3	0.9961	1.44502	1.44771	1.45431	1.45977	(71)
$C_{13}H_{20}O_6$	Diethyl propionylmalonate *O*-propionate	19.1	1.0790	1.44843	1.45106	1.45868	1.46488	(34)
$C_{13}H_{20}O_8$	Tetraethyl methanetetracarboxylate	13.5	1.1401	1.43375	1.43593	1.44162	1.44633	(35)
$C_{13}H_{22}O_2$	Ethoxymethylenementhone	15.15	0.9696	1.48587	1.48945	1.49954	1.50907	(17)
$C_{13}H_{22}O_2$	Ethyl α-(1, 3-dimethyl-cyclohexylidene)-5-propionate	18.7	0.9702	1.50227	1.50753	1.52136	1.53443	(84)
$C_{13}H_{22}O_4$	Diethyl *cis*-hexahydrohomophthalate	21.1	1.0394	1.45129	1.45363*	1.45913	1.46386	(73)
$C_{13}H_{22}O_4$	Diethyl *trans*-hexahydrohomophthalate	21.2	1.0369	1.45039	1.45283*	1.45833	1.46277	(73)
$C_{13}H_{22}O_4$	*o*-Ethyl allomethylcamphorate	17.7	1.0569	1.45809	1.46042		1.47063	(99)
$C_{13}H_{22}O_4$	*o*-Methyl alloethylcamphorate	17.1	1.0492	1.45656	1.45889		1.46905	(99)
$C_{13}H_{23}NO_4$	Diethyl *N*-methylpyrrolidinediacetate	15.5	1.0472	1.45723	1.45969	1.46607	1.47148	(25)
$C_{13}H_{24}O_2$	Hexylpropiolic acetal	12.1	0.8808	1.4398	1.4424	1.4483	1.4530	(150)
$C_{13}H_{26}O_2$	*n*-Decyl propionate	20	0.8639	1.42696	1.42907	1.43434	1.43863	(163)
$C_{13}H_{28}O$	Propyl *n*-decyl ether	20	0.7969	1.42273	1.42487	1.43019	1.43444	(163)
$C_{14}H_{12}$	α-Phenylstyrene	20	1.0232	1.60089	1.60849	1.62730	1.64482	(45)
$C_{14}H_{12}$	9-Methylfluorene	66.2	1.0263	1.60233	1.61009	1.63189		(48)
$C_{14}H_{12}O$	Diphenylacetaldehyde	21.9	1.0986	1.58500	1.59114*	1.60646	1.62043	(28)
$C_{14}H_{14}$	*p*-Methyldiphenylmethane	19.3	0.9978	1.56579	1.57103	1.58571	1.59804	(48)
$C_{14}H_{14}O$	1-Ethyl-4-acetylnaphthalene	15.7	1.0922	1.61139	1.61979	1.64374	1.66762	(145)
$C_{14}H_{14}O_2$	Ethyl α-methyl-β-naphthoate	22.1	1.1103	1.58638	1.59408*	1.61423	1.63293	(70)
$C_{14}H_{14}O_3$	Ethyl 1-methoxy-2-naphthoate	17.7	1.1486	1.58180	1.58923	1.60964	1.62908	(48)
$C_{14}H_{14}O_3$	Ethyl 3-methoxy-2-naphthoate	17.7	1.1616	1.59336	1.60090	1.62243	1.64306	(48)
$C_{14}H_{15}N$	Dibenzylamine	21.6	1.0256	1.56885	1.57432	1.58817	1.60017	(106)
$C_{14}H_{15}NO$	β-Acetylethylaminonaphthalene	23.1	1.0893	1.59614	1.60312	1.62261	1.64039	(145)
$C_{14}H_{16}$	1, 4-Diethylnaphthalene	13.1	0.9983	1.59005	1.59699	1.61642	1.63423	(145)
$C_{14}H_{16}$	1, 3-Dimethyl-5-phenyl-3, 5-cyclohexadiene	17.0	0.9722	1.56824	1.57486	1.59322	1.61083	(83)
$C_{14}H_{16}N_2$	1-Benzyltetrahydroindazole	17.0	1.0923	1.56906	1.57393*	1.58576	1.59629	(60)
$C_{14}H_{16}N_2$	2-Benzyltetrahydroindazole	16.1	1.0903	1.57124	1.57620*	1.58836	1.59912	(60)
$C_{14}H_{16}O$	Octracenone	62.4	1.0760	1.56549	1.57072	1.58603		(64)
$C_{14}H_{16}O$	1-Ketooctahydrophenanthrene	100.1	1.0638	1.55863	1.56282	1.57821		(64)
$C_{14}H_{16}O_2$	Ethyl Δ^1-α-methyl-β-naphthoate	15.6	1.0906	1.56723	1.57438*	1.59295	1.61143	(70)
$C_{14}H_{16}O_2$	Ethyl α-methylcinnamylideneacetate	18.7	1.0421	1.60262	1.61553*	1.65283	1.69588	(27)
$C_{14}H_{16}O_2$	Ethyl β-methylcinnamylideneacetate	25.1	1.0384	1.58849	1.59936*	1.63013	1.66379	(27)
$C_{14}H_{16}O_2$	Ethyl γ-methylcinnamylideneacetate	20.3	1.0387	1.59010	1.60100*	1.63176	1.66551	(27)
$C_{14}H_{16}O_3$	1-Ethyl-3, 5-dimethyl-2-acetoxycoumarone	20.4	1.0776	1.52527	1.53010	1.54381	1.55630	(23)
$C_{14}H_{16}O_3$	1-Isopropyl-4-methyl-2-acetoxycoumarone	19.1	1.0823	1.52377	1.52846	1.54241	1.55466	(23)
$C_{14}H_{16}O_4$	Diethyl benzalmalonate	20.4	1.1045	1.53242	1.53894	1.55697	1.57444	(45)
$C_{14}H_{16}O_4$	Ethyl 4-methyl-2-ethoxycoumarilate	52.6	1.1044	1.53367	1.54037	1.55855	1.57637	(41)
$C_{14}H_{17}N$	α-Diethylaminonaphthalene	18.1	1.0071	1.58611	1.59331	1.61410	1.63305	(145)
$C_{14}H_{17}N$	β-Diethylaminonaphthalene	21.6	1.0242	1.62219	1.63210	1.66216	1.69595	(145)
$C_{14}H_{18}$	Octahydroanthracene	88.8	0.9648	1.53230	1.63625	1.54791	1.55788	(64)
$C_{14}H_{18}$	Octahydrophenanthrene	12.8	1.0313	1.56588	1.57006	1.58189	1.59185	(64)
$C_{14}H_{18}$	1, 3-Dimethyl-5-phenyl-3-cyclohexene	15.3	0.9462	1.53131	1.53617	1.54773	1.55799	(83)
$C_{14}H_{18}$	1-Phenyl-6-methyl-1, 3-heptadiene	14.9	0.9486	1.57364	1.58232	1.60620	1.63025	(45)
$C_{14}H_{18}O$	Benzal dipropyl ketone	23.9	0.9718	1.54116	1.54761	1.56514	1.58203	(8)
$C_{14}H_{18}O_2$	Ethyl *p*, α, β-trimethylcinnamate	18.35	1.0027	1.51483	1.51915	1.53187	1.54290	(14)
$C_{14}H_{18}O_3$	Ethyl α-(β-phenylethyl)-acetoacetate	24.15	1.0441	1.49260	1.49636*	1.50548	1.51329	(70)
$C_{14}H_{20}O_4$	Methyl acetylcamphorcarboxylate	19.8	1.0823	1.48128	1.48439	1.49202	1.49847	(43,† 115)

Formula	Name	t, °C	d^t_4	α	D	β	γ	Lit.
$C_{14}H_{20}O_9$	Tetraethyl oxalylmethanetricarboxylate	15.45	1.1671	1.43820	1.44026	1.44627		(35)
$C_{14}H_{22}O_2$	Butyrylcamphor	17.35	1.0161	1.48900	1.49233	1.50088	1.50844	(119)
$C_{14}H_{22}O_2$	Ethyl α-(1, 3-dimethyl-3, 5-cyclohexadiene)-5-isobutyrate	13.4	0.9689	1.48605	1.48950	1.49858	1.50654	(84)
$C_{14}H_{22}O_3$	Ethyl ethylisophoronecarboxylate	19	1.0109	1.47936	1.48288	1.49148	1.49921	(44)
$C_{14}H_{22}O_4$	Diethyl *dl*-dehydrocamphorate	16.4	1.0399	1.46313	1.46588	1.47287	1.47879	(9)
$C_{14}H_{24}N_2$	Tetraethyl-*o*-phenylenediamine	12.6	0.9267	1.51676	1.52134	1.53467	1.54654	(145)
$C_{14}H_{24}N_2$	Tetraethyl-*m*-phenylenediamine	11.8	0.9522	1.54778	1.55367	1.57051	1.58588	(145)
$C_{14}H_{24}O_4$	Diethyl camphorate	26.2	1.0244	1.45127	1.45354	1.45906	1.46347	(97)
$C_{14}H_{24}O_4$	Diethyl *d-cis*-camphorate	19.1	1.0319	1.45386	1.45613	1.46179	1.46649	(80)
$C_{14}H_{24}O_4$	Diethyl *l-trans*-camphorate	21.6	1.0286	1.45226	1.45454	1.46015	1.46506	(80)
$C_{14}H_{24}O_7$	Tetraethyl citrate	20	1.1022	1.44582	1.44844	1.45476		(93)
$C_{14}H_{28}O_2$	*n*-Decyl butyrate	20	0.8617	1.42867	1.43077	1.43613	1.44048	(163)
$C_{14}H_{28}O_2$	Heptyl heptoate	18.8	0.86492	1.42692	1.43177	1.43718	1.44155	(125)
$C_{14}H_{30}O$	Dimethylundecyl carbinol	81.8		1.41520	1.41736*	1.42249	1.42675	(127)
$C_{14}H_{30}O$	Butyl decyl ether	20	0.8009	1.42565	1.42777	1.43302	1.43735	(163)
$C_{15}H_{12}O_3$	Methyl *o*-benzoylbenzoate	19.65	1.1900	1.58480	1.59128	1.60874	1.62492	(49)
$C_{15}H_{14}$	*m*-Methylstilbene	60.5	0.9891	1.62501	1.63628	1.66982		(48)
$C_{15}H_{14}$	α-Phenyl-β-methylstyrene	63.5	0.9813	1.57197	1.57913	1.59638	1.61169	(45)
$C_{15}H_{14}O$	3-Allyl-2-hydroxydiphenyl	18.7	1.0735	1.59411	1.60107*	1.61850	1.63439	(87)
$C_{15}H_{14}O_6$	Diethyl phthalylmalonate	84.4	1.1887	1.53416	1.54105	1.56155		(36)
$C_{15}H_{16}$	1-Phenyl-1-*p*-tolylethane	17.2	0.9847	1.56038	1.56590	1.57962	1.59192	(13)
$C_{15}H_{16}O$	3-Propyl-2-hydroxydiphenyl	16.0	1.0512	1.57462	1.58063*	1.59606		(87)
$C_{15}H_{16}O$	1-Methyl-4-ethyl-2-acetylnaphthalene	15.1	1.0737	1.60390	1.61183	1.63455	1.65676	(145)
$C_{15}H_{18}$	1-Methyl-2, 4-diethylnaphthalene	13.3	0.9870	1.58549	1.59231	1.61135	1.62870	(145)
$C_{15}H_{18}O$	*o*, *o*, *p*-Triallylphenol	12.75	0.9801	1.53963	1.54451	1.55776	1.56937	(47)
$C_{15}H_{18}O$	*o*, *o*-Diallylphenol allyl ether	12.75	0.9563	1.52144	1.52583	1.53792	1.54823	(47)
$C_{15}H_{18}O_2$	4, 7-Dimethyl-2, 2-diethylindanedione	62.4	1.0174	1.52107	1.52598	1.54051		(36)
$C_{15}H_{19}NO_2$	Tropacocaine	100.1	1.0426	1.50440	1.50801	1.51840	1.52707	(25)
$C_{15}H_{20}O_6$	Triallyl tricarballylate	15.9	1.0973	1.46461	1.46747	1.47463	1.48076	(71)
$C_{15}H_{20}O_7$	Triallyl citrate	17.4	1.1358	1.46798	1.47142	1.47839	1.48439	(71)
$C_{15}H_{20}O_{10}$	Tetraethyl dioxalylmalonate	14.9	1.1926	1.45378	1.45665	1.46452	1.47138	(35)
$C_{15}H_{22}O_3$	Methyl allylcamphorcarboxylate	20.2	1.0670	1.48839	1.49113	1.49783	1.50326	(114)
$C_{16}H_{16}O_4$	Diethyl naphthalate	70.0	1.1399	1.55245	1.55863	1.57648	1.59319	(48)
$C_{16}H_{18}$	2-Phenylcymene	15	0.9776	1.56228	1.56797	1.58266	1.59626	(143)
$C_{16}H_{18}$	2-Phenylmenthatriene	15	0.9752	1.56307	1.56914	1.58476	1.59911	(143)
$C_{16}H_{18}O_2$	*o*, *o*-Diethoxydiphenyl	47.4	1.0430	1.55479	1.56022	1.57603	1.59014	(48)
$C_{16}H_{20}O_5$	Diethyl α-oxalyl-γ-phenylbutyrate	15.75	1.1162	1.49164	1.49526	1.50439		(70)
$C_{16}H_{22}O_4$	Ethyl α, α-diethyl(*o*-methoxybenzoyl) acetate	12.3	1.0931	1.51272	1.51742	1.52868	1.53909	(19)
$C_{16}H_{24}O_5$	Diethyl camphoric carbonate	19.4	1.0765	1.47417	1.47417	1.48140	1.48729	(43,† 97)
$C_{16}H_{25}ClO_3$	Amyl chlorocamphocarboxylate	19.0	1.0906	1.48391	1.48655	1.49285	1.49800	(116)
$C_{16}H_{26}O$	Phenyl *n*-decyl ether	20	0.8981	1.48279	1.48618	1.49474	1.50213	(163)
$C_{16}H_{26}O_3$	Isoamyl camphocarboxylate	17.2	1.0143	1.47343	1.47596	1.48197	1.48685	(113,† 122)
$C_{16}H_{27}N$	Diamylaniline	24.9	0.8893	1.50368	1.50826		1.53074	(106)
$C_{17}H_{14}Br_2O_2$	Ethyl 2, 7-dibromofluorene-9-acetate	99.8	1.5121	1.60527	1.61300	1.63481	1.65429	(145)
$C_{17}H_{16}O_2$	Ethyl α-phenylcinnamate	18 55	1.0971	1.58973	1.59723	1.61959		(45)
$C_{17}H_{20}$	2-Benzylcymene	15	0.9690	1.55138	1.55650	1.56958	1.58098	(143)
$C_{17}H_{21}NO_4$	*d*-φ-Cocaine	99.6	1.1020	1.49862	1.50218	1.51199	1.51959	(25)
$C_{17}H_{21}NO_4$	*dl*-φ-Cocaine	99.5	1.1026	1.49867	1.50209	1.51193	1.51996	(25)
$C_{17}H_{36}$	*n*-Heptadecane	79.0		1.41105	1.41320*	1.41832	1.42251	(127)
$C_{18}H_{18}O_2$	Ethyl α-benzylcinnamate	16.1	1.0831	1.58163	1.58850	1.60717		(45)
$C_{18}H_{20}$	1, 4-Diphenyl-1-ethyl-3-butene	22.8	0.9892	1.58083	1.58749	1.60490	1.62049	(44)
$C_{18}H_{26}N_2$	1, 4-Diethylaminonaphthalene	99.6	0.9318	1.53320	1.53943	1.55827	1.57731	(145)
$C_{18}H_{26}N_2$	1, 5-Diethylaminonaphthalene	26.8	0.9889	1.56740	1.57421	1.59428	1.61449	(145)
$C_{18}H_{26}N_2$	1, 8-Diethylaminonaphthalene	18.0	1.0124	1.58707	1.59508	1.61916	1.64005	(145)
$C_{18}H_{28}O$	Undecyl phenyl ketone	52.4	0.900	1.48149	1.48503	1.49425		(8)
$C_{18}H_{28}O_4$	Amyl acetylcamphorcarboxylate	20.5	1.0223	1.47426	1.47717	1.48438	1.49049	(43,† 115)
$C_{18}H_{28}O_4$	Ethyl isovalerylcamphorcarboxylate	22.7	1.0219	1.47366	1.47644	1.48390	1.48995	(43,† 115)
$C_{19}H_{20}$	*meso*-Isoamylanthracene	71.1	1.0017	1.62491	1.63636	1.67152		(22)
$C_{19}H_{22}$	Dihydro-*meso*-isoamylanthracene	44.4	0.9940	1.55791	1.56261	1.57651	1.58868	(22)
$C_{20}H_{28}O_2$	2, 3-Diamylhydroxynaphthalene	19.5	0.9919	1.54057	1.54621	1.56187		(48)
$C_{20}H_{28}O_2$	2, 7-Diamylhydroxynaphthalene	99.6	0.9335	1.51043	1.51547	1.53068		(48)
$C_{20}H_{28}O_2$	1, 5-Dihydroxynaphthalenediamyl ether	99.9	0.9411	1.51083	1.51602	1.53128		(145)

Formula	Name	t, °C	d_4^t	α	D	β	γ	Lit.
$C_{20}H_{40}$	Dimethylhexadecylethylene	79.1		1.42600	1.42847*	1.43434	1.43931	(127)
$C_{20}H_{40}O_2$	*n*-Decyl caprate	20	0.8586	1.44006	1.44232	1.44783	1.45236	(163)
$C_{20}H_{42}O$	Di-*n*-decyl ether	20	0.8187	1.43955	1.44182	1.44743	1.45206	(163)
$C_8H_{20}Sn$	Tetraethyl tin		1.4089	1.5065	1.5143		1.5403	(132)
$C_8H_{20}Pb$	Dimethylethylisobutyl lead	20.7	1.6234	1.50327	1.50783	1.51982	1.53010	(136)
$C_8H_{20}Pb$	Methyldiethylpropyl lead	22.1	1.6403	1.50925	1.51412	1.52638	1.53710	(136)
$C_9H_{22}Pb$	Dimethylethylisoamyl lead	21.7	1.5579	1.50079	1.50524	1.51662	1.52647	(136)
$C_{10}H_{24}Pb$	Dimethylpropylisoamyl lead	22	1.5028	1.49773	1.50201	1.51313	1.52251	(136)
$C_{10}H_{24}Pb$	Methyldiethylisoamyl lead	20.8	1.5225	1.50336	1.50783	1.51921	1.52934	(136)
$C_{10}H_{24}Pb$	Tri-*n*-propylmethyl lead	22.3	1.5220	1.50456	1.50911	1.52059	1.53058	(137)
$C_{11}H_{26}Pb$	Diethylpropylisobutyl lead	20	1.4890	1.50751	1.51195	1.52353	1.53359	(136)
$C_{11}H_{26}Pb$	Methylethyl-*n*-propylisoamyl lead	21.0	1.4792	1.50189	1.50636	1.51747	1.52720	(136)
$C_{11}H_{26}Pb$	Tri-*n*-propylethyl lead	21.3	1.4846	1.50703	1.51149	1.52290	1.53299	(137)
$C_{12}H_{28}Pb$	Diethylpropylisoamyl lead	22.1	1.4392	1.50217	1.50655	1.51758	1.52721	(136)
$C_{13}H_{30}Pb$	Triisobutylmethyl lead	19.6	1.3977	1.49883	1.50321	1.51397	1.52324	(137)
$C_{13}H_{30}Pb$	Tri-*n*-propylisobutyl lead	22.6	1.4034	1.50235	1.50673	1.51766	1.52716	(137)
$C_{14}H_{32}Pb$	Triisobutylethyl lead	22.1	1.3758	1.50134	1.50552	1.51636	1.52573	(137)
$C_{14}H_{32}Pb$	Tri-*n*-propylisoamyl lead	21.0	1.3810	1.50049	1.50465	1.51535	1.52462	(137)
$C_{15}H_{34}Pb$	Triisobutyl-*n*-propyl lead	19.6	1.3505	1.50148	1.50561	1.51631	1.52554	(137)
$C_{16}H_{36}Pb$	Tetraisobutyl lead	20.2	1.3240	1.50004	1.50416	1.51461	1.52375	(137)
$C_{16}H_{36}Pb$	Triisoamylmethyl lead	22	1.3134	1.49226	1.49618	1.50612	1.51477	(137)
$C_{17}H_{38}Pb$	Triisoamylethyl lead	19.6	1.2922	1.49425	1.49825	1.50818	1.51669	(137)
$C_{17}H_{38}Pb$	Triisobutylisoamyl lead	20.6	1.2976	1.49696	1.50097	1.51118	1.51989	(137)
$C_{18}H_{40}Pb$	Triisoamyl-*n*-propyl lead	22	1.2737	1.49324	1.49703	1.50696	1.51542	(137)
$C_{19}H_{42}Pb$	Triisoamylisobutyl lead	19.5	1.2522	1.49242	1.49618	1.50597	1.51428	(137)
$C_{20}H_{44}Pb$	Tetraisoamyl lead	20.5	1.2332	1.49075	1.49457	1.50404	1.51232	(137)

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Every substance appearing in this section is entered in Table 1 in its proper place, as determined by its formula, in standard (resp. ℭ-) arrangement. It appears as a B-component in the section devoted to aqueous solutions, or as an A-component in other sections. At that place reference by serial number is given to each other place at which it occurs. Each system in the dispersion table (Table 5) has the same serial number as in Table 1 or 2.

In most cases observers have aimed at relative, and not absolute accuracy, hence such a tabulation as that here given subjects the data to a purpose never intended by the observer. A number of gross errors have been detected; some seem to be certainly errors in transcription and some of these have been corrected; the source of others cannot be determined. A number of such errors, one as great as 0.1% of n, occur in the data of Krollpfeiffer (76); he seems to have much over-estimated the accuracy of his data.

Eine jede in diesem Teil enthaltene Substanz befindet sich in Tafel 1 an der Stelle, welche ihr durch die Formel in der Standard- (bezw. ℭ-) Anordnung zukommt. Die Substanz ist entweder als B-Komponente in dem Abschnitt der wässrigen Lösungen enthalten, oder sie befindet sich als A-Komponente in den anderen Abschnitten. An dieser Stelle wird durch eine Serienzahl der Hinweis, zu jeder anderen Stelle gegeben, wo sie vorhanden ist. Jedes System in der Dispersions-Tafel 5 hat dieselbe Serienzahl wie in der Tafel 1 oder 2.

In vielen Fällen haben die Beobachter eine relative statt eine absolute Genauigkeit angestrebt. Daher werft ein Tafel, wie der hier zusammengestellte, die Daten einem Zwecke unter, der von dem Beobachter nie beabsichtigt war. Eine Anzahl grober Fehler sind aufgefunden worden. Einige davon sind sicher Übertragungsfehler und einige davon sind korrigiert; die Quelle anderer konnte nicht aufgefunden werden. Solche Fehler bis 0,1% in n kommen in den Daten von Krollpfeiffer (76) vor, es scheint als ob dieser Autor die Genauigkeit seiner Zahlen sehr überschätzt hätte.

Chaque substance mentionnée dans cette section est située dans la Table 1 à sa propre place, ainsi qu'elle est déterminée par sa formule dans l'arrangement type (resp. arrangement ℭ). Elle est considérée comme un constituant B dans la section se rapportant aux solutions aqueuses, ou comme un constituant A dans les autres sections. À cette place il est donné une référence par un nombre de série se rapportant à chaque autre place à laquelle la substance se présente. Dans la table de dispersion (Table 5) chaque système a le même nombre de série que dans la Table 1 ou 2.

Dans la plupart des cas, les expérimentateurs ont eu pour but d'obtenir une précision relative et non absolue, par conséquent un arrangement en tableaux tel qu'il est donné ici, soumet les données à un but qui n'a jamais été visé par l'expérimentateur. Un certain nombre d'erreurs grossières a été décelé; quelques unes paraissent être certainement des erreurs de transcriptions et certaines de celles-ci ont été corrigées; la source des autres n'a pu être déterminée. Un certain nombre de telles erreurs, dont l'une atteint 0,1% de n, se trouve dans les données de Krollpfeiffer (76); cet auteur semble avoir beaucoup surestimé la précision de ses données.

Le sostanze comprese in questo capitolo sono situate nella Tabella 1 al posto che ad esse spetta, secondo la formula scritta col sistema tipo (o col sistema ℭ). Esse figurano come componente B nella sezione dedicata alle soluzioni acquose o come componente A nelle altre sezioni. In quel posto è indicato a mezzo del numero di serie quali sono gli altri posti dove ciascuna sostanza è nominata. Ogni sistema ha nella Tabella 5 lo stesso numero di serie che nella Tabella 1 o 2.

Nel maggior numero dei casi gli osservatori si sono prefissi di raggiungere un'accuratezza relativa e non già assoluta; l'ordinamento dei dati nella maniera qui adoperata li fa servire perciò ad uno scopo non previsto dagli sperimentatori. Sono stati rilevati parecchi errori notevoli, alcuni sembra che debbono essere certamente attribuiti alla trascrizione, e sono stati corretti. L'origine degli altri non si è potuta stabilire. Parecchi di tali errori—uno arriva fino al 0,1% di n—si trovano fra i valori di Krollpfeiffer (76); sembra che questi abbia apprezzato molto al di là del giusto l'accuratezza dei suoi valori.

SYMBOLS

a, b, c	Coefficients in $n = a + b(10)^{-3}(\% B) + c(10)^{-6}(\% B)^2$.
g B/kg A	Number of grams of B per 1000 grams of A in a binary mixture.
M_A/M_B	Molecular dilution of B = number of moles of A per mole of B in a binary mixture.
$d_{t'}^{t''}$	Specific gravity at t''°C with reference to water at t'°C.
eq.	Equilibrium.
Isom.	Isomer.
k	$n = n_0 + k(\text{g B/l soln.})(10)^{-4}$.
max.	Maximum value of.
M_B/l soln.	Number of gram moles of B per liter of mixture.
n	Index of refraction.
n_λ^t	Index of refraction at t°C, for light of wave-length λ.
N	Number of gram-equivalents of B per liter of mixture.
% B	Number of grams of B per 100 grams of mixture = Wt. % of B.
V_A	Unit volumes of constituent A.
Vol. % B, t°	Volume of pure B, at t°C, per 100 cm³ of mixture, at t°C = Vol. % of B.
g B/l soln.	Number of grams of B per liter of mixture.
α	$dn/dt = -\alpha \times 10^{-4}$.
δ_d	$1000 d_4^t = 1000 + \delta_d$.
δ_n	$1000 n_D^t = 1333 + \delta_n$.
ϵ	Accuracy of n is $\pm 0.0001\epsilon$.
λ	Wave-length of light.
$\binom{\lambda_1}{\lambda_2}$	$(n_{\lambda_2} - n_{\lambda_1}) = \binom{\lambda_1}{\lambda_2} \times 10^{-5}$. The λ's may be indicated by the Fraunhofer letter notation.
#	Indicates a place for which no digit is given; *e.g.*, 5# indicates that the value is nearer 50 than 40 or 60, but the second digit is not known.

SYMBOLE

a, b, c,	Koeffizient von $n = a + b(10)^{-3}(\% B) + c(10)^{-6}(\% B)^2$.
g B/kg A	Anzahl von Grammen des Stoffes B auf 1000 g von A in einer binären Mischung.
M_A/M_B	Molekulare Verdünnung von B = Zahl der Mole von A auf Mole von B in der binären Mischung.
$d_{t'}^{t''}$	Spezifisches Gewicht bei t''°C auf Wasser bei t'°C bezogen.
eq.	Gleichgewicht.
Isom.	Isomer.
k	$n = n_0 + k(\text{g B/l soln.})(10)^{-4}$.
max.	Maximaler Wert von.
M_B/l soln.	Zahl der Gramm-Mole von B pro Liter der Mischung.
n	Brechungsindex.
n_λ^t	Brechungsindex bei t°C, für Licht von der Wellenlänge λ.
N	Zahl der Gramm-Äquivalente von B pro Liter der Mischung.
% B	Zahl der Gramme von B pro 100 g der Mischung = Gewichts % von B.
V_A	Einheitsvolumen des Bestandteiles A.
Vol. % B, t°	Volumen des reinen B bei t°C pro 100 cm³ der Mischung bei t°C = Vol. % von B.
g B/l soln.	Zahl der Gramme von B pro Liter der Mischung.
α	$dn/dt = -\alpha \times 10^{-4}$.

SYMBOLES

a, b, c	Coefficients dans $n = a + b(10)^{-3}(\% B) + c(10)^{-6}(\% B)^2$.
g B/kg A	Nombre de grammes de B pour 1000 grammes de A dans le mélange binaire.
M_A/M_B	Dilution moléculaire de B = nombre de molécules de A pour une molécule de B dans le mélange binaire.
$d_{t'}^{t''}$	Poids spécifique à t''°C par rapport à de l'eau à t'°C.
eq.	Équilibre.
Isom.	Isomère.
k	$n = n_0 + k(\text{g B/l soln.})(10)^{-4}$.
max.	Valeur maximum de.
M_B/l soln.	Nombre de Mol. gr. de B par litre de mélange.
n	Indice de réfraction.
n_λ^t	Indice de réfraction à t°C pour une lumière de longueur d'onde λ.
N	Nombre d'équivalents grammes de B par litre de mélange.
% B	Nombre de grammes de B pour 100 grammes de mélange = % poids de B.
V_A	Volumes unités du constituant A.
Vol. % B, t°	Volume de B pur à t°C pour 100 cm³ de mélange à t°C = % Vol. de B.
gB/l soln.	Nombre de grammes de B par litre de mélange.
α	$dn/dt = -\alpha \times 10^{-4}$.
δ_d	$1000 d_4^t = 1000 + \delta_d$.
δ_n	$1000 n_D^t = 1333 + \delta_n$.
ϵ	La précision de n est $\pm 0{,}0001\epsilon$.
λ	Longueur d'onde de la lumière.
$\binom{\lambda_1}{\lambda_2}$	$(n_{\lambda_2} - n_{\lambda_1}) = \binom{\lambda_1}{\lambda_2} \times 10^{-5}$. Les λ peuvent être indiquées par les lettres de la notation de Fraunhofer.
#	Indique une place pour laquelle aucun chiffre n'est donné; par ex., 5# indique que la valeur est plus rapprochée de 50 que de 40 ou de 60, mais que le second chiffre n'est pas connu.

SIMBOLI

a, b, c,	Coefficienti in $n = a + b(10)^{-3}(\% B) + c(10)^{-6}(\% B)^2$.
g B kg A	Numeri di grammi di B per 1000 grammi di A in una miscela binaria.
M_A/M_B	Diluizione molecolare di B = numero di molecole di A per molecole di B in una miscela binaria.
$d_{t'}^{t''}$	Peso specifico a t''°C rispetto all'acqua a t'°C.
eq.	Equilibrio.
Isom.	Isomero.
k	$n = n_0 + k(\text{g B/l soln.})(10)^{-4}$.
max.	Massimo valore di.
M_B/l soln.	Numero di grammi molecole di B per litro di miscela.
n	Indice di rifrazione.
n_λ^t	Indice di rifrazione a t°C, per luce di lunghezza d'onda λ.
N	Numero di grammi equivalenti di B per litro di miscela.
% B	Numero di grammi di B per 100 grammi di miscela = peso % di B.
V_A	Volumi unitari del costituente A.
Vol. % B, t°	Volume di B puro a t°C, per 100 cm³ di miscela a t°C = Vol. % di B.

δ_d	$1000d_4^t = 1000 + \delta_d$.
δ_n	$1000n_D^t = 1333 + \delta_n$.
ϵ	Genauigkeit von n ist $\pm 0{,}0001\epsilon$.
λ	Wellenlänge des Lichtes.
$\binom{\lambda_1}{\lambda_2}$	$n_{\lambda_2} - n_{\lambda_1} = \binom{\lambda_1}{\lambda_2} \times 10^{-5}$. Die λ-Werte können nach der Bezeichnungsweise von Fraunhofer gekennzeichnet werden.
#	Zeigt eine Stelle an, für welche keine Ziffer vorliegt; z. B. 5# gibt an, dass der Wert näher an 50 als an 40 oder 60 liegt, aber die zweite Ziffer ist nicht bekannt.

g B/l soln.	Numero di grammi di B per litro di miscela.
α	$dn/dt = -\alpha \times 10^{-4}$.
δ_d	$1000d_4^t = 1000 + \delta_d$.
δ_n	$1000n_D^t = 1333 + \delta_n$.
ϵ	La precisione di n è $\pm 0{,}0001\epsilon$.
λ	Lunghezza d'onda della luce.
$\binom{\lambda_1}{\lambda_2}$	$(n_{\lambda_2} - n_{\lambda_1}) = \binom{\lambda_1}{\lambda_2} \times 10^{-5}$. I λ possono essere indicati con la notazione di Fraunhofer, in lettere.
#	Indica un posto per il quale nessuna cifra viene data; per es., 5# indica che il valore è più vicino a 50 che a 40 o 60, ma la seconda cifra non si conosce

Arithmetical Relations.—For many binary mixtures, n is an additive function of the volume composition of the mixture: $100(n/d)_m = [n_1(\%)_1/d_1] + [n_2(\%)_2/d_2]$ where the subscript m indicates that the quantity refers to the mixture, but if there is a change in volume this relation does not hold. If $100/d_v \equiv [(\%)/d]_1 + [(\%)/d]_2$, $100/n_v \equiv [(\%)/n]_1 + [(\%)/n]_2$, $C_v \equiv (d_m - d_v)/d_m$, and $C_n \equiv (n_m - n_v)/n_m$, where d_m and n_m are the observed values of d and n for the mixture, then $A \equiv C_v/C_n$ has been called the "refraction constant" (133) of the mixture. It varies but slightly with temperature and wave-length. The equation $(d_m - d_v)/d_m = A(n_m - n_v)/n_m$ is called Pulfrich's formula. Levi (81) used the formula $(d_m - d_v)/d_m = A'(n_m - N_v)/(n_m - 1)$, where $100(N_v - 1)/d_v = [(\%)(n - 1)/d]_1 + [(\%)(n - 1)/d]_2$, and Doroszewski (37) has shown that for aqueous solutions of nicotine ($C_{10}H_{14}N_2$) and of trimethyl carbinol ($C_4H_{10}O$) A' is independent of the concentration. Hubbard (70) showed that for a number of mixtures Pulfrich's formula with n replaced by $(n^2 - 1)/(n^2 + 2)$ gives a value of A which is independent of the concentration.

Wave-lengths of the Spectral Lines Used in This Section

In column (2) is the symbol of the chemical element which is the source of the line; in (3) is the Greek letter, and in (4) is the Fraunhofer designation of the line. Unit of λ = 1 Å = 10^{-8} cm.

λ	(2)	(3)	(4)	λ	(2)	(3)	(4)
2314				4679			
2574				4861	H	β	*F*
2749				4961	Hg	(Blue)	
2981				5351	Tl	(Green)	
3256				5780*	Hg		
3405				5790	Hg	(Yellow)	
3612				5876	He		
4047	Hg			5893*	Na		*D*
4341	H	γ	*G'*	6563	H	α	*C*
4358	Hg	(Violet)		6708	Li	(Red)	

* Mean value of the doublet.

TABLE 1.—REFRACTIVITY AT ONE WAVE-LENGTH: BINARY MIXTURES

Also formula index for all substances covered by this report.

For dispersion and refraction at other wave-lengths, *see* Table 5. Substances of unknown composition are given at the end of Sections I and II*b*.

The index of refraction (n_λ^t) is here tabulated for one or another of the following values of λ: 6563 Å (*C*, Hα), 5893 (*D*), 5876 (He), 5790 (Hg), 4861 (*F*, Hβ), 3256. (Pulfrich), (Abbe-Zeiss) . . . indicate type of refractometer used; (Kahlbaum) = material obtained from Kahlbaum. E = equivalent weight of B, $n = a + b(\%\ B)(10)^{-3} + c(\%\ B)^2(10)^{-6} \pm 0.0001\epsilon$, $n = n_0 + k(\text{g B/l soln.})(10)^{-4} \pm 0.0001\epsilon$. For a given mixture the value of N_B and of g B/l soln. varies with the temperature. Unit of λ = 1 Å = 10^{-8} cm. t = centigrade temperature, °C.

Two-Component Systems

Standard Arrangement, *v.* Vol. III, p. viii; A = H_2O

The refraction of the H_2O used in making the solution is not on record unless it is given below, or the authority is (38, 65, 85, 86); the values given by the latter are: $n_D^{15} = 1.33345$ (38), $n_{3256}^{18} = 1.35326$ (65), $n_D^{70} = 1.32522$ (85), $n_D^{18} = 1.33322$ (86).

𝔄-𝔅-Table

1. HCl

g B/kg A (41)*	n_D^{25}	n_D^{30}
8.02	1.33432	1.33389
17.72	1.33651	1.33608
26.81	1.33847	1.33802
36.92	1.34060	1.34019
46.07	1.34255	1.34210
54.79	1.34433	1.34393
65.90	1.34662	1.34613
73.81	1.34816	1.34769
84.67	1.35025	1.34977
93.49	1.35190	1.35144
103.3	1.35374	1.35325
114.6	1.35590	1.35534
148.6	1.36187	1.36130
160.3	1.36395	1.36336

N_{18} (64)	n_D^{18}
0.5	1.33753
1.0	1.34168
2.0	1.34977
4.0	1.36480

* Dipping refractometer; C. P. HCl + dist. H_2O; g B/kg A checked by $Ba(OH)_2$ standardized by HCl checked against Ag (41).

2. $HClO_3$ (64)

N_{18}	n_D^{18}
0.5	1.33773
1.0	1.34211
2.0	1.35078
3.0	1.35927

3. HBr (64)

0.1	1.33452
0.2	1.33579
0.5	1.33952
1.0	1.34571
2.0	1.35805
4.0	1.38271

3.1. I (22)

4. HI (64)

0.1	1.33525
0.2	1.33734
0.5	1.34346
1.0	1.35387
2.0	1.37497

5. HIO_3 (64); *see also* 535, 536*

N_{18}	n_D^{18}
0.1	1.33568
0.2	1.33802
0.5	1.34498
1.0	1.35642
2.0	1.37910
4.0	1.42393

* If $N_{21} = 0.5$, $n_D^{21} = 1.3444$ (28); if g B/l soln., 25° = 4.4867, $n_D^{25} = 1.33311$, $d_4^{25} = 1.00093$ (113).

6. HIO_4 (28); *see also* 537–539

N_{26}	n_D^{26}
0.5	1.3445

6.1. S; *see* 229 (5, 42, 85)

7. H_2SO_4 (95 to 96% H_2SO_4); electrically heated SiO_2 prism; n corrected to air at 20°C and 1 atm. (15); *see also* Table 5

t	n_D^t
28.4	1.4245
49.1	1.4198
85.8	1.4119
113.8	1.4058
173.9	1.3924
206.8	1.3848
264.2	1.3709
307.5	1.3591

7.1. Se; *see* 229

8. H_2SeO_3 and H_2SeO_4; ϵ about 5; t = 20°C (146); λ = 5893 (*D*); *see also* 540

% B	H_2SeO_3	H_2SeO_4
2	1.3350	1.3352
4	1.3371	1.3377
6	1.3394	1.3401
8	1.3417	1.3425
10	1.3441	1.3450
12	1.3467	1.3476
14	1.3492	1.3501
16	1.3517	1.3527
18	1.3543	1.3555

8.—(*Continued*)

% B	H_2SeO_3	H_2SeO_4
20	1.3570	1.3583
22	1.3598	1.3611
24	1.3628	1.3639
26	1.3658	1.3669
28	1.3689	1.3699
30	1.3721	1.3730
32	1.3755	1.3762
34	1.3789	1.3794
36	1.3823	1.3826
38	1.3858	1.3858
40	1.3895	1.3892
42	1.3935	1.3926
44	1.3977	1.3960
46	1.4020	1.3996
48	1.4064	1.4032
50	1.4109	1.4068
52	1.4156	1.4106
54	1.4205	1.4146
56	1.4255	1.4188
58	1.4305	1.4232
60	1.4358	1.4278
62	1.4414	1.4325
64	1.4474	1.4373
66	1.4537	1.4423
68	1.4603	1.4475
70	1.4670	1.4529
72	1.4741	1.4584
74	1.4816	1.4640
76	1.4893	1.4696
78	1.4971	1.4753
80		1.4810
82		1.4879
84		1.4935
86		1.4989
88		1.5038
90		1.5085
91		1.5106
92		1.5124
93		1.5140
94		1.5153
95		1.5163
96		1.5169
97		1.5171
98		1.5172
99		1.5160

9. **NH_4OH** (28); *see also* 537, 540, 543, 544, and (50)

N_t	n_D^t	t
0.5	1.3326	25
2.0	1.3352	15

10. **HNO_3** (94); *see also* 541, 542

d_4^{20}	n_D^{20}
1.0209	1.3385
1.0253	1.3394
1.0373	1.3423

11. **NH_4F** (64)

N_{18}	n_D^{18}
0.1	1.33385
0.2	1.33441
0.5	1.33599
1.0	1.33836
2.0	1.34246
4.0	1.34882

12. **NH_4Cl** (14, 56)

N_{20}	n_D^{20}
1.0	1.34311*
0.1	1.3341
1.0	1.3438
1.0	1.3429 (30°)

* Salt dried at 100°C (56).

13. **$(NH_4)_2SO_4$** (35); best commercial material; *see also* 545, 546

M_B/M_A	n_D^t	d_4^t	t
11.06	1.39275	1.2267	16
11.24	1.39246*	1.2259	17

* If g B/l soln., 25° = 26.440, n_D^{25} = 1.33679, d^{25} = 1.01244 (113).

14. **NH_4NO_3**

N_{20} (56)	n_D^{20}
0.5	1.33776
1.0	1.34251
% B, 25° (95)	**n_D^{25}**
10.49	1.3455
12.10	1.3458
20.59	1.3582
27.55	1.3680
49.38	1.3999
62.03	1.4185

15. **P_2O_5** (113); *see also* 547

g B/l soln., 25°	n_D^{25}	d_4^{25}
3.2267	1.33341	1.00079

16. **H_3PO_3** (28); *see also* 543, 548

M_B/l soln., t°	n_D^t	t
2.0	1.3507	12*
2.0	1.3479	17.5

* t = 12 to 12.5°C.

16.1. **H_3PO_4**; *see* 549

17. **$H_4P_2O_7$** (28); *see also* 550

0.5	1.3435	15

18. **As_2O_3** (2)

g B/l soln.	n_D^{22}	d_{25}^{25}
1.796	1.33309	1.0014
3.212	1.33326	1.0025
5.060	1.33348	1.0039
5.670	1.33355	1.0044
6.425	1.33363	1.0050
7.436	1.33381	
10.13	1.33417	1.0080
12.85	1.33450	1.0102
14.368	1.33469	1.0113

g B/l soln. = 1288.39d − 1288.36.

g B/l soln. = 7550n − 10062.7.

α = 0.97 if 20° < t < 27°.

19. **As_2O_5** (113); *see also* 551

g B/l soln., 25°	n_D^{25}	d_4^{25}
12.7597	1.33444	1.00845

19.1. **As_2S_3**; *see* (83)

19.2. **Sb_2S_3**; *see* (83)

ℭ-Table; The ℭ-Arrangement

𝔄-𝔅-Table *continued on p. 70*

20. **CH_2O**, Formaldehyde (107)

% B	n_D^t
t = 15°C	
0	1.3334
1	1.3345
2	1.3358
3	1.3369
4	1.3382
5	1.3394
6	1.3406
7	1.3418
8	1.3430
9	1.3442
10	1.3454
11	1.3467
12	1.3478
13	1.3489
14	1.3501
15	1.3513
16	1.3525
17	1.3538
18	1.3549
19	1.3560
20	1.3572
21	1.3583
22	1.3597
23	1.3608
24	1.3619
25	1.3629
26	1.3640
27	1.3651

If 0 < % B < 10, b = 1.2, c = 0, ϵ = 1 or 2.

If 10 < % B < 27, b = 1.215, c = −1.4, ϵ = 1 or 2.

21. **NH_4CNS** (64)

N_{18}	n_D^{18}
0.1	1.33506
0.2	1.33686
0.5	1.34222
1.0	1.35121
2.0	1.36894
4.0	1.40406

M_B/M_A*	n_D^t	d_4^t	t
4.71	1.45521	1.1114	15
6.28	1.43617	1.0944	15
12.32	1.39634	1.0585	16

* Crystallized from 96 % C_2H_5OH (35).

22. **CH_4O**, Methyl alcohol; *see also* 254–302

% B	n_D^t
t = 15°C (38)	
0	1.33339
2	1.33384
5	1.33453
7	1.33504
10	1.33584
12	1.33644
15	1.33730
20	1.33879

22.—(*Continued*)

% B	n_D^t
t = 15°C.—(*Cont'd*)	
25	1.34022
30	1.34138
35	1.34235
40	1.34308
45	1.34359
50	1.34378
55	1.34365
60	1.34327
65	1.34272
70	1.34179
75	1.34067
80	1.33925
85	1.33749
90	1.33545
95	1.33309
100	1.33057

Max. n_D^{15} = 1.34380 at % B = 51.

t = 15.5°C, Zeiss (67)	
0.00*	1.33336
15.10	1.33728
18.18	1.33820
20.25	1.33888
22.86	1.33987
26.23	1.34090
30.77	1.34184
37.21	1.34279
47.06	1.34358
54.24	1.34369
64.00	1.34294
70.33	1.34184
78.05	1.34002
87.67	1.33663
100.00†	1.33057

t = 17°C (39)	
0.0	1.3335
5.7	1.3346
11.0	1.3358
15.0	1.3371
19.5	1.3386
26.0	1.3401
31.4	1.3415
35.0	1.3422
39.7	1.3430
45.2	1.3434
46.8	1.3435
51.1	1.3436
56.0	1.3434
60.5	1.3429
65.2	1.3424
69.8	1.3417
74.6	1.3404
78.4	1.3394
80.1	1.3389
84.8	1.3372
89.9	1.3350
94.6	1.3327
100.0	1.3304

Max. n_D^{17} = 1.3436 at % B = 51.1.

22.—(*Continued*)

% B	n_D^t
t = 25°C (51)	
0.00	1.33232
21.70	1.33823
37.66	1.34090
52.22	1.34163
54.23	1.34163
64.35	1.34065
68.20	1.33984
80.44	1.33663
86.27	1.33505
92.48	1.33193
100.00	1.32773

Max. n_D^{25} = 1.34170 at % B = 53.

* $d_4^{15.5}$ = 0.99904.

† $d_4^{15.5}$ = 0.7956.

23. **$C_2HCl_3O_2$**, Trichloroacetic acid (155)

% B*	n_D^t	d_4^t	t
10.1570	1.34616	1.05090	19.9
17.1480	1.35577	1.08931	19.7
27.2570	1.37006	1.14742	19.8
41.9490	1.38968	1.23408	20.2
57.8790	1.41300	1.34088	19.7

* Unit not stated, probably wt. %.

24. **$C_2H_2O_4$**, Oxalic acid (113)

g B/l soln., 25°	n_D^{25}	d_4^{25}
3.1407	1.33289	0.99866

25. **$C_2H_4O_2$**, Acetic acid (41); *see also* 310–315

g B/kg A	n_D^{25}	n_D^{30}
0.00	1.33251	1.33204
25.37	1.33427	1.33366
47.42	1.33569	1.33509
71.75	1.33720	1.33657
92.93	1.33848	1.33779
120.41	1.34001	1.33926
152.45	1.34172	1.34092
179.87	1.34308	1.34223
220.39	1.34493	1.34405
239.65	1.34579	1.34490
266.89	1.34694	1.34598
303.94	1.34838	1.34740
333.44	1.34949	1.34847
367.90	1.35068	1.34964
405.32	1.35187	1.35077
407.12	1.35226	1.35115

g B/l soln., 25°	n_D^{25}(113)	d_4^{25}
183.753	1.35110	1.03235

26. **$C_2H_4O_3$**, Glycolic acid (113)

40.4302	1.33632	1.01006

27. **C_2H_5BrO**, Ethylenebromohydrin; t = 20°C (106)

% B	n_D^t
0.000	1.3330
3.361	1.3358
10.010	1.3422
18.810	1.3517
22.441	1.3561
30.999	1.3667
40.372	1.3790

27.—(*Continued*)

% B	n_D^t
49.179	1.3915
53.620	1.3980
60.586	1.4095
72.201	1.4299
80.007	1.4454
90.032	1.4671
95.340	1.4801
100.000	1.4915

28. **C_2H_6O**, Ethyl alcohol; *see also* 320–348

% B	n_D^t
t = 15°C (38)	
0	1.33345
10	1.34020
20	1.34778
30	1.35470
40	1.35948
46	1.36170
50	1.36290
55	1.36405
60	1.36505
65	1.36586
70	1.36645
75	1.36676
80	1.36690
85	1.36678
90	1.36626
95	1.36518
100	1.36332

Max. n_D^{15} = 1.36690 at % B = 80.

% B	n_D^t
t = 15.5°C, Zeiss (66)	
0.00	1.33336
6.00	1.33721
11.33	1.34105
17.56	1.34581
20.35	1.34787
22.11	1.34919
24.21	1.35075
26.06	1.35162
26.80	1.35250
29.87	1.35443
33.82	1.35654
38.98	1.35883
46.00	1.36152
56.09	1.36408
59.35	1.36471
63.01	1.36535
68.32	1.36591
72.50	1.36630
83.63	1.36651
91.09	1.36574
100.00	1.36316
t = 17.5°C (139)	
0.00	1.33320
0.99	1.33367
1.80	1.33416
2.60	1.33466
3.41	1.33517
4.22	1.33568
8.32	1.33843
16.25	1.34441
26.31	1.35043
35.67	1.35565

28.—(*Continued*)

% B	n_D^t
t = 17.5°C.—(*Cont'd*)	
45.27	1.35953
55.42	1.36248
66.05	1.36448
77.21	1.36565
83.75	1.36587
88.46	1.36565
95.04	1.36448
100.00	1.36229

Max. $n_D^{17.5}$ = 1.36587 at % B = 83.75.

% B	n_D^t
t = 18°C (93)	
0.00	1.3331
18.5	1.3451
41.2	1.3589
60.8	1.3633
74.0	1.3650
91.9	1.3635
100.00	1.3599

t = 20°C (12)

Vol. % B, t°	n_D^t	$d_{15.5}^{15.5}$
2.85	1.3333	0.9958
3.56	1.3335	0.9948
4.95	1.3341	0.9929
10.08	1.3370	0.9865
20.08	1.3432	0.9759
29.83	1.3492	0.9656
40.00	1.3545	0.9518
50.15	1.3585	0.9340
60.10	1.3615	0.9132
69.99	1.3633	0.8899
80.00	1.3648	0.8637
84.82	1.3650	0.8499
90.01	1.3643	0.8337
94.97	1.3635	0.8160
99.50	1.3618	0.7961

t = 25°C (hydrogen scale) (3); *cf.* (77); claims $\epsilon = 0.1$, probably $\epsilon > 0.1$; Zeiss; n against air; for the C_2H_6O used, d_4^{25} = 0.78510 ± 0.00001

% B	n_D
70	1.363038
74	1.363208
75	1.363239
76	1.363265
77	1.363286
78	1.363302
79	1.363313
79.3	1.363315
80	1.36331
81	1.36326
82	1.36319
83	1.36312
84	1.36305
85	1.36297
86	1.36290
87	1.36280
88	1.36269
89	1.36255
90	1.36239
91	1.36221

28.—(*Continued*)

% B	n_D^t
92	1.36200
93	1.36178
94	1.36153
95	1.36125
96	1.36094
97	1.36061
98	1.36024
99	1.35984
100	1.35941

Max. n_D^{25} = 1.363315 at % B = 79.3.

(41)

% B	n_D^{25}	n_D^{30}
0.00	1.33251	1.33204
2.43	1.33402	1.33351
3.96	1.33498	1.33444
5.62	1.33604	1.33550
7.66	1.33739	1.33679
9.48	1.33864	1.33807
11.45	1.34001	1.33934
13.93	1.34181	1.34111
15.34	1.34278	1.34204
17.43	1.34428	1.34342
19.44	1.34566	1.34476
21.56	1.34709	1.34609
23.16	1.34818	1.34718
25.45	1.34961	1.34847
27.72	1.35086	1.34974
28.43	1.35123	1.35000

(113)

% B	n_D^{25}
0.0	1.3331
18.5	1.3451
41.2	1.3589
60.8	1.3633
74.0	1.3650
91.9	1.3605
100.0	1.3599

29. **$C_2H_6O_2$**, Glycol (112); n_D^{20} = 1.33298 + 0.00009600 (g B/l soln.)

30. **$NH_4CH_3CO_2$**, Acetate (47)

$N_{19.5}$	$n_D^{19.5}$	$d_{19.5}^{19.5}$
$\frac{1}{16}$	1.3338	1.0007
$\frac{1}{8}$	1.3343	1.0015
$\frac{1}{4}$	1.3354	1.0036
$\frac{1}{2}$	1.3376	1.0070
1	1.3416	1.0142
2	1.3504	1.0276
4	1.3670	1.0523

N_{18} (64)	n_D^{18}
0.5	1.33883
1.0	1.34423
2.0	1.35470
4.0	1.37435

31. **$(NH_4)_2C_2O_4.H_2O$**, Oxalate; t = 18°C (47)

N_{18}	n_D^{18}	d_4^{18}
$\frac{1}{16}$	1.3339	1.0021
$\frac{1}{8}$	1.3345	1.0042
$\frac{1}{4}$	1.3365	1.0084
$\frac{1}{2}$	1.3397	1.0168

32. C_3H_6O, Acetone; $t = 25°C$ (51); *see also* 349–358

% B	n_D^t
0.00	1.33232
25.90	1.35009
45.50	1.35940
51.50	1.36135
61.70	1.36261
76.30	1.36315
87.96	1.36208
94.90	1.35957
100.00	1.35545

Max. $n_D^{25} = 1.36320$ at % B = 73.5.

33. $C_3H_6O_2$, Propionic acid; *see also* 359

$t = 19°C$ (39)

% B	n_D^t
50.3	1.3730
56.3	1.3764
62.5	1.3798
68.5	1.3830
74.4	1.3858
80.0	1.3878
86.0	1.3891
89.9	1.3899
92.9	1.3897
96.1	1.3891
97.5	1.3885
99.0	1.3879
100.0	1.3872

% B* (155)	n_D^t	d_4^t	t
8.0930	1.34044	1.00580	19.9
23.7180	1.35397	1.01750	19.8
62.1330	1.38004	1.02511	19.6
68.2130	1.38439	1.02424	18.7
97.7850	1.38760	0.99382	19.8
98.0120	1.38819	0.99403	18.7

g B/l soln., 25°	n_D^{25} (113)	d_4^{25}
221.397	1.35092	1.01362

* Unit not stated, probably wt. %.

33.1. $C_3H_6O_3$, Lactic acid (113)

93.8597	1.34326	1.02179

34. C_3H_8O, *n*-Propyl alcohol; *see also* 360, 361

% B	n_D^t
$t = 15°C$ (38)	
0	1.3333
10	1.3429
20	1.3523
30	1.3590
40	1.3651
50	1.3705
60	1.3754
70	1.3795
80	1.3831
90	1.3860
100	1.3873
$t = 20°C$ (150)	
0.00	1.33296
9.72	1.34195
26.44	1.35555
28.72	1.35713
34.71	1.36072
42.99	1.36526
50.46	1.36899
57.73	1.37243
61.62	1.37415
71.20	1.37798
78.41	1.38053
86.41	1.38299
93.34	1.38451
100.00*	1.38499

$t = 20°C$ (12)

Vol. % B, $t°$	n_D^t	d_{15}^{15}
2.85	1.3330	0.9984
3.56	1.3340	0.9958
4.95	1.3365	0.9916
10.08	1.3402	0.9869
20.08	1.3483	0.9760
29.83	1.3533	0.9652
40.00	1.3576	0.9517
50.15	1.3630	0.9340
60.10	1.3680	0.9135
69.99	1.3738	0.8897
80.00	1.3790	0.8638
90.01	1.3840	0.8341
99.5	1.3855	0.8098

* $d_4^{15} = 0.8075$.

35. C_3H_8O, Isopropyl alcohol

$t = 20°C$ (12)

2.85	1.3335	0.9962
3.56	1.3340	0.9952
4.95	1.3375	0.9888
10.08	1.3392	0.9866
20.08	1.3478	0.9755
29.83	1.3542	0.9654
40.00	1.3590	0.9520
50.15	1.3632	0.9345
60.10	1.3678	0.9137
69.99	1.3712	0.8900
80.00	1.3745	0.8640
90.01	1.3769	0.8338
94.97	1.3770	0.8160
99.50	1.3775	0.7953

$t = 15°C$ (38)

% B	n_D^t
0	1.3333
10	1.3427
20	1.3522
30	1.3601
40	1.3655
50	1.3700
55	1.3718
60	1.3736
70	1.3764
75	1.3775
80	1.3785
85	1.3792
90	1.3797
95	1.3797
100	1.3792

Max. $n_D^{15} = 1.3798$ at % B = 94.

36. $C_3H_8O_3$, Glycerol

% B	n_D^t
$t = 25°C$ (73)	
0	1.3333
5	1.3394
10	1.3455
15	1.3516
20	1.3577
25	1.3641
30	1.3709
35	1.3777
40	1.3846
45	1.3917
50	1.3985
55	1.4058
60	1.4131
65	1.4204
70	1.4281
75	1.4357
80	1.4435
85	1.4506
90	1.4576
95	1.4651
100	1.4730

$t = 20°C$ (112)

$n_D^{20} = 1.33298 + 0.00011778$ (g B/l soln.)

37. $C_4H_6O_4$, Succinic acid (113)

g B/l soln., 25°	n_D^{25}	d_4^{25}
45.8425	1.33730	1.01077

38. $C_4H_6O_5$, Malic acid (113)

168.079	1.35156	1.05782

39. $C_4H_6O_6$, Tartaric acid (53); *see also* 563, 564

% B	n_D^t	d_4^t
$t = 11°C$		
0.00	1.3325	
10.45	1.3474	1.0497
17.79	1.3576	1.0871
25.44	1.3684	1.1274
31.65	1.3779	1.1618
38.26	1.3881	1.2006
44.28	1.3979	1.2370

a = 1.3345, b = 1.195, c = 5.25, ϵ = 2 or 3.

% B	n_D^t	d_4^t
$t = 11.5°C$		
24.62	1.3669	1.1221
29.10	1.3742	1.1468
33.49	1.3807	1.1716
37.82	1.3872	1.1969
41.35	1.3925	1.2180
49.35	1.4015	1.2490
$t = 14.3°C$		
1.07	1.3349	1.0043
2.84	1.3369	1.0122
4.84	1.3395	1.0214
6.93	1.3423	1.0313
7.31	1.3428	1.0335
9.83	1.3462	1.0454
$t = 20°C$		
0.00	1.3330	
2.00	1.3356	1.0077
4.91	1.3393	1.0211
9.61	1.3451	1.0429
18.46	1.3565	1.0864
26.64	1.3686	1.1294
34.22	1.3801	1.1714
41.31	1.3910	1.2131
47.88	1.4023	1.2540

a = 1.3330, b = 1.185, c = 5.25, ϵ = 2 or 3.

g B/l soln., 25°	n_D^{25} (113)	d_4^{25}
73.6565	1.34145	1.02960
200.00	1.35626	1.08440

40. $NH_4HC_4H_4O_6$, Acid tartrate; $t = 18°C$ (47)

N_t	n_D^t	d_t^t
$\frac{1}{16}$	1.3342	1.0031
$\frac{1}{8}$	1.3358	1.0062

41. $C_4H_{10}O$, Trimethyl carbinol (37)

% B	n_D^{25}	d_4^{25}
0.00	1.33284	0.99713
9.99	1.34316	0.9820
19.97	1.35330	0.9669
29.96	1.36056	0.9455
39.98	1.36635	0.9222
49.96	1.37147	0.8988
59.96	1.37585	0.8753
69.84	1.37935	0.8519
79.92	1.38220	0.8282
89.92	1.38411	0.8044
100.00	1.38548	0.78602

Pulfrich's formula (p. 65) applies accurately. Data reduced to vacuum.

42. $C_4H_{10}O_4$, Erythritol (112)

$n_D^{20} = 1.33298 + 0.00013097$ (g B/l soln.)

43. $(NH_4)_2C_4H_4O_4$, Succinate; $t = 17.5°C$ (47)

N_t	n_D^t	d_t^t
$\frac{1}{16}$	1.3337	1.0015
$\frac{1}{8}$	1.3345	1.0032
$\frac{1}{4}$	1.3366	1.0065
$\frac{1}{2}$	1.3398	1.0131
1	1.3455	1.0261
2	1.3575	1.0510
4	1.3804	1.0973

44. $(NH_4)_2C_4H_4O_6$, Tartrate; $t = 18°C$ (47)

$\frac{1}{16}$	1.3344	1.0020
$\frac{1}{8}$	1.3356	1.0045
$\frac{1}{4}$	1.3375	1.0100
$\frac{1}{2}$	1.3419	1.0209
1	1.3495	1.0411
2	1.3642	1.0802
4	1.3931	1.1532

45. $C_5H_4O_2$, 2-Furaldehyde (132)

t	n_{5876}^t
4.6217 % B	
24.05	1.34107
37.85	1.33902

45.—(*Continued*)

t	n^t_{5876}
5.6935 % B	
23.8	1.34310
35.4	1.34143
6.5624 % B	
21.75	1.34496
31.85	1.34351
96.340 % B	
23.7	1.51682
30.3	1.51336
100.000 % B	
22.1	1.52497
32.3	1.51978
46.5	1.51255
75.0	1.49788

46. C_5H_5N, Pyridine; *see also* 372–374

% B	n^t_D
t = 15°C (45)	
0	1.3341
5	1.3435
10	1.3532
15	1.3632
20	1.3731
25	1.3829
30	1.3927
35	1.4025
40	1.4123
45	1.4219
50	1.4317
55	1.4414
60	1.4516
65	1.4616
70	1.4710
75	1.4799
80	1.4884
85	1.4960
90	1.5028
95	1.5088
100	1.5136

If $0 < \% B < 60$, $b = 1.95$, $c = 0$, $\epsilon = 1$ or 2.

t = 25.2°C (152); *cf.* (82)

% B	n^t_D
0*	1.33266
11.63	1.35433
20.99	1.37122
31.18	1.38981
41.54	1.40874
50.97	1.42591
60.36	1.44306
71.50	1.46295
81.43	1.47976
91.39	1.49475
100.00†	1.50677

* $d_4^{25.2} = 0.99971$.
† $d_4^{25.2} = 0.99776$.

47. $NH_4C_5H_9O_2$, Valerate; t = 20°C (47)

N_t	n^t_D	d^t_t
$\frac{1}{16}$	1.3340	1.0002
$\frac{1}{8}$	1.3345	1.0006
$\frac{1}{4}$	1.3361	1.0015
$\frac{1}{2}$	1.3386	1.0036
1	1.3440	1.0071
2	1.3545	1.0141
4	1.3751	1.0263

48. C_6H_6O, Phenol (83); 8.2 % B

t	Solution		H_2O	
	n^t_D	δ_d	δ_n	δ_d
17.6	1.34800	5.0		
18	1.34792	5.0	0.14	−1.4
19	1.34755	4.8	0.06	−1.6
20	1.34749	4.5	−0.02	−1.8

49. C_6H_7N, Aniline (4); *see also* 400–402

100 − % B	n^{20}_D
0.0000	1.58685
1.0484	1.58396
2.1232	1.58114
3.0571	1.57861

$n^{20}_D = 1.58685 - 0.00270 (100 - \%B)$. $\alpha = 3.0$ and almost independent of t. Saturated at $(100 - \% B) = 4.835$, for which $d^{20}_{20} = 1.02393$.

50. $C_6H_8O_7$, Citric acid (113)

g B/l soln., 25°	n^{25}_D	d^{25}_t
89.8126	1.34253	1.03039
M_B/l soln., 15°	n^{15}_D (28)	
2.0	1.3800	

51. $C_6H_{12}O_6$, Fructose (109, 111)

t = 20°C, $n_D(H_2O) = 1.33298$

Isom.	k
β	1.4366
α, β(eq.)	1.4100

52. $C_6H_{12}O_6$, Glucose; t = 20°C (109, 111); n_D (H_2O) = 1.33298

α	1.423637
β	1.437518
α, β(eq.)	1.4325
g B/l soln., t°	n^t_D (108)
0	1.33298
253	1.36946*
253	1.36961†
280	1.37380*
280	1.37397‡

* Age of solution: 10 min.
† 24 hr.
‡ 6 hr.

53. $C_6H_{14}O_6$, Dulcitol (112)

$n^{20}_D = 1.33298 + 0.00014254$ (g B/l soln.)

54. $C_6H_{14}O_6$, *d*-Mannitol (112)

$n^{20}_D = 1.33298 + 0.00014216$ (g B/l soln.)

55. $C_6H_{14}O_6$, *d*-Sorbitol (112)

$n^{20}_D = 1.33298 + 0.00014327$ (g B/l soln.)

56. $C_6H_{15}N$, Triethylamine (83); 5 % B

t	Solution		H_2O	
	n^t_D	δ_d	δ_n	δ_d
17	1.33840	− 9.5	+0.21	−1.2
18	1.33821	−10.0	+0.14	−1.4
19	1.33777	−10.4	+0.06	−1.6
20	1.33798	−10.5	−0.02	−1.8
21	1.33813	−10.7	−0.10	−2.0
22	1.33823	−10.9	−0.19	−2.2
23	1.33835	−11.3	−0.28	−2.5
24	1.33845	−11.7	−0.37	−2.7
25	1.33875	−11.9	−0.47	−3.1

57. $(NH_4)_3C_6H_5O_7$, Citrate; t = 17.5°C (47)

N_t	n^t_D	d^t_t
$\frac{1}{16}$	1.3344	1.0023
$\frac{1}{8}$	1.3352	1.0046
$\frac{1}{4}$	1.3372	1.0092
$\frac{1}{2}$	1.3411	1.0187
1	1.3487	1.0364
2	1.3636	1.0700
4	1.3903	1.1321

58. $NH_4C_7H_5O_2$, Benzoate; t = 20°C (47)

N_t	n^t_D	d^t_t
$\frac{1}{16}$	1.3359	1.0019
$\frac{1}{8}$	1.3376	1.0040
$\frac{1}{4}$	1.3414	1.0082

59. $NH_4C_7H_5O_3$, Salicylate; t = 20°C (47)

N_t	n^t_D	d^t_t
$\frac{1}{16}$	1.3360	1.0023
$\frac{1}{8}$	1.3384	1.0052
$\frac{1}{4}$	1.3429	1.0111
$\frac{1}{2}$	1.3521	1.0228
1	1.3692	1.0461

60. $C_7H_{12}O_6$, Quinic acid (113)

g B/l soln., 25°	n^{25}_D	d^{25}_4
53.8721	1.34027	1.01722

61. $C_7H_{14}O_6$, Methylglucoside; 10 % B, t = 20°C (110)

$n^{20}_D(H_2O) = 1.33298$

Isom.	n^{20}_D	d^{20}_4
α	1.34680	1.031022
β	1.34688	1.030670

62. $C_8H_8O_2$, Phenylacetic acid (113)

g B/l soln., 25°	n^{25}_D	d^{25}_4
5.8743	1.33357	0.99800

63. $C_8H_8O_3$, Phenylglycolic acid (113)

84.7143	1.34783	1.01704

64. $C_{10}H_{14}N_2$, Nicotine

% B	n^t_D
t = 15°C (45)	
0	1.3341
5	1.3443
10	1.3546
15	1.3652
20	1.3760
25	1.3868
30	1.3976
35	1.4083
40	1.4193
45	1.4303
50	1.4413
55	1.4523
60	1.4633
65	1.4743
70	1.4852
75	1.4950
80	1.5035
85	1.5118
90	1.5193
95	1.5255
100	1.5300

64.—(*Continued*) — t = 15°C.—(*Cont'd*)

% B (81)	n^t_D	t
0.00	1.33274	25.0
3.72	1.34058	22.5
10.01	1.35336	22.9
14.92	1.36321	23.9
24.17	1.38327	22.5
30.08	1.39472	25.5
37.46	1.41073	23.0
44.54	1.42576	24.4
50.24	1.43789	23.8
57.17	1.45324	23.8
63.30	1.46602	24.0
66.78	1.47277	24.5
73.04	1.48582	24.6
79.65	1.49724	25.4
88.66	1.51215	24.8
100.00	1.52682	25.0

n^t_D can be computed by Pulfrich's formula (p. 65) with an accuracy of ±0.0001 or ±0.0002.

65. $C_{12}H_{22}O_{11}$, Lactose

% B	n^t_D	d^t_4
t = 18.5°C (53)		
4.65	1.3400	1.0172
7.56	1.3433	1.0273
14.35	1.3551	1.0580
18.47	1.3604	1.0716
22.51	1.3670	1.0888
26.97	1.3746	1.1093

66. $C_{12}H_{22}O_{11}$, Sucrose

t = 16.5°C (53)

% B	n^t_D	d^t_4
2.97	1.3377	1.0107
4.63	1.3400	1.0169
4.95	1.3404	1.0181
6.36	1.3425	1.0239
6.86	1.3433	1.0256
8.49	1.3457	1.0325
9.29	1.3470	1.0360
9.72	1.3476	1.0376
11.04	1.3498	1.0433
16.06	1.3577	1.0643
18.36	1.3615	1.0742
21.48	1.3666	1.0888
21.66	1.3669	1.0895
23.99	1.3712	1.1002
29.91	1.3813	1.1280
30.91	1.3836	1.1329
40.09	1.4006	1.1783

66.—(*Continued*)

% B	n_D^t	d_4^t
t = 18.5°C (53)		
5.01	1.3406	1.0185
9.77	1.3478	1.0379
14.20	1.3546	1.0561
18.67	1.3618	1.0758
22.92	1.3689	1.0942
26.98	1.3760	1.1134
31.00	1.3835	1.1331
34.80	1.3902	1.1510
38.53	1.3974	1.1694
42.14	1.4042	1.1885
49.12	1.4184	1.2250
59.59	1.4380	1.2789

66.—(*Continued*)

% B	n_D^t (91)	t
74.55	1.47051	50.3
78.37	1.48063	48.5
78.37	1.47801	60.7
78.37	1.47783	61.4
78.37	1.47500	73.5
78.37	1.47486	74.3

If $72 < \% B < 81$ and $30° < t < 75°$, $n_D^t = 1.28534 + 0.00263 \times (\% B) - (124.1 + 1.267(\% B)) \times t(10)^{-6}$, the fifth figure of n_D^t being unreliable.

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Proteins, *v.* Table 4

𝔄-𝔅-Table.—(*Continued*)

66.1. **SiO_2,** *see* 570 (83)

66.2. **SnO_2** (83)

66.3. **$SnCl_4$,** *see* 237

67. **$Pb(NO_3)_2$;** t = 18°C (86)

N_t	n_D^t
0.5	1.34279
1.0	1.35210
2.0	1.37034

68. **$Pb(C_2H_3O_2)_2$,** Acetate; t = 18°C (64)

0.1	1.33511
0.2	1.33691
0.5	1.34213
1.0	1.35075
2.0	1.36770
N_t (65)	n_{3256}^t
0.4971	1.36359
0.9725	1.37323
2.006	1.39412

69. **$ZnCl_2$** (Abbe-Zeiss); t = 20°C (14)

N_t	n_D^t
0.1	1.3350
1.0	1.3470
1.0	n_D^{30} = 1.3462

70. **$Zn(ClO_3)_2$;** t = 18°C (64)

0.1	1.33476
0.2	1.33618
0.5	1.34043
1.0	1.34730
2.0	1.36083
4.0	1.38616

71. **$Zn(NO_3)_2$;** t = 18°C (64)

0.1	1.33466
0.2	1.33603
0.5	1.34008
1.0	1.34675
2.0	1.35971
4.0	1.38415

72. **$Zn(C_2H_3O_2)_2$,** Acetate (47)

N_{22}	n_D^{22}	d_{22}^{22}
$\frac{1}{16}$	1.3331	1.0028
$\frac{1}{8}$	1.3345	1.0064
$\frac{1}{4}$	1.3361	1.0140
$\frac{1}{2}$	1.3395	1.0281
1	1.3454	1.0548
2	1.3569	1.1071

73. **$CdCl_2$** (Pulfrich) (49)

% B	n_D^{25}	d_4^{25}
1.599	1.33517	1.0115
4.472	1.33929	1.0368
8.620	1.34499	1.0695
11.600	1.35088	1.1068
18.690	1.36316	1.1803
21.201	1.36833	1.2165
26.076	1.37850	1.2700
31.090	1.38925	1.3401
41.540	1.41710	1.5153

74. **$CdCl_2.2H_2O$** (Abbe-Zeiss); t = 20°C (14)

N_t	n_D^t
0.1	1.3348
1.0	1.3465
1	n_D^{30} = 1.3458

75. **$Cd(ClO_3)_2$;** t = 18°C (64)

0.5	1.34061
1.0	1.34775
2.0	1.36193
4.0	1.38442

76. **$CdBr_2$** (Pulfrich) (49)

% B	n_D^{25}	d_4^{25}
1.05	1.33330	1.0059
2.76	1.33623	1.0212
5.41	1.34001	1.0470
11.03	1.34782	1.1016
15.66	1.35500	1.1509
21.13	1.36425	1.2133
27.51	1.37624	1.2991
40.74	1.40373	1.4918

77. **CdI_2** (Pulfrich) (49); *see also* 254, 320

0.834	1.33368	1.0042
3.340	1.33714	1.0249
3.880	1.33780	1.0303
6.984	1.34228	1.0581
13.491	1.35258	1.1216
20.133	1.36435	1.1933
26.785	1.37839	1.2780
39.860	1.41104	1.4801

(Abbe-Zeiss), t = 20°C (14)

N_t	n_D^t
0.1	1.3360
1	1.3575
1	n_D^{30} = 1.3570

78. **$Cd(NO_3)_2$;** t = 18°C (64)

N_t	n_D^t
0.1	1.33468
0.2	1.33507
0.5	1.34018
1.0	1.34694
2.0	1.36013
4.0	1.38508

79. **$HgCl_2$;** t = 18°C (86); *see also* 572–574

0.3	1.33668
0.5	1.33900

If N_{18} = 0.2, n_D^{18} = 1.3381 (148). If g B/l soln., 25° = 54.18, n_D^{25} = 1.33712, d_4^{25} = 1.04160 (113).

79.1. **HgI_2;** *see* 571

79.2. **$Hg(NO_3)_2$;** *see* 541

79.3. **$Hg_2(NO_3)_2$;** *see* 542

80. **$Cu(ClO_3)_2$;** t = 18°C (86)

0.5	1.34086
1	1.34830
2	1.36269
4	1.39013
(64)	
0.1	1.33482
0.2	1.33634
0.5	1.34087
1.0	1.34835
2.0	1.36278
4.0	1.39013

81. **$Cu(NO_3)_2$;** t = 18°C (86)

0.5	1.34050
1	1.34749
2	1.36130
4	1.38751
(64)	
0.1	1.33473
0.2	1.33619
0.5	1.34050
1.0	1.34756
2.0	1.36138
4.0	1.38756

82. **AgF;** t = 18°C (64)

0.1	1.33465
0.2	1.33602
0.5	1.33982
1.0	1.34583
2.0	1.35647
3.0	1.36703

83. **$AgNO_3$** (113); *see also* 575, 576

g B/l soln., 25°	n_D^{25}	d_4^{25}
169.97	1.34976	1.13615

84. **$MnCl_2$;** t = 18°C (86); *see also* 590

N_t	n_D^t
0.5	1.33978
1	1.34623
2	1.35866
6	1.40498

84.—(*Continued*)

N_{18} (65)	n_{3256}^{18}
0.4995	1.36064
1.013	1.36805
2.024	1.38220
4.042	1.40909

g B/kg A	n_D^{20} (17)	α*
2.5	1.3355	1.1_3
6.3	1.3361	1.0_0
12.6	1.3374	1.1_3

* If 15° < t < 30°C.

85. **$MnBr_2$** (86)

N_{18}	n_D^{18}
0.5	1.34183
1	1.35030
2	1.36682
4	1.39898

86. **$MnSO_4$** (17); *see also* 577, 578, 590

g B/kg A	n_D^{20}	α*
3.0	1.3353	1.2_0
7.5	1.3357	1.0_0
15.0	1.3371	1.0_0

* If 15° < t < 30°C.

87. **$Mn(NO_3)_2$** (86); *see also* 577, 590

N_{18}	n_D^{18}
0.5	1.33963
1	1.34592
2	1.35810

g B/kg A	n_D^{20} (17)	α*
3.6	1.3357	1.0_7
9.0	1.3360	1.0_7
18.0	1.3378	1.1_3

* If 15° < t < 30°C.

88. **$FeCl_2$;** t = 18°C (86)

N_t	n_D^t
0.5	1.34038
1	1.34742
2	1.36064
4	1.38631

89. **$FeCl_3$;** t = 18°C (86); *see also* 579, 591

0.5	1.34055
1	1.34769
2	1.36138
4	1.38805
(Abbe-Zeiss) t = 20°C (14)	
0.1	1.3350
1.0	1.3480
1	n_D^{30} = 1.3471

g B/kg A	n_D^{20} (17)	α*
3.3	1.3365	1.1_3
8.3	1.3388	1.2_0
16.6	1.3431	1.2_7

* If 15° < t < 30°.

90. **$FeBr_2$** (86)

N_{18}	n_D^{18}
0.5	1.34237
1	1.35137
2	1.36910
4	1.40314
5	1.41982

91. **$Fe_2(SO_4)_3$** (17); *see also* 578, 580, 591

g B/kg A	n_D^{20}	α^*
8.4	1.3363	1.0_7
20.1	1.3386	1.1_3
40.2	1.3422	1.2_0

* If 15° < t < 30°C.

92. **$Fe(NO_3)_3$** (86); *see also* 580, 580.1, 591

N_{18}	n_D^{18}
0.5	1.34054
1	1.34769
2	1.36178
4	1.38917

g B/kg A	n_D^{20} (17)	α^*
4.8	1.3366	1.0_7
12.0	1.3391	1.0_7
24.0	1.3434	1.0_0

* If 15° < t < 30°C.

93. **$CoCl_2$** (86); *see also* 581, 592

N_{18}	n_D^{18}
0.5	1.34055
1	1.34759
2	1.36127
4	1.38725

g B/kg A	n_D^{20} (17)	α^*
2.6	1.3360	1.0_0
6.5	1.3368	1.0_7
13.1	1.3382	1.0_7

* If 15° < t < 30°C.

94. **$Co(ClO_3)_2$** (86)

N_{18}	n_D^{18}
0.5	1.34055
1	1.34766
2	1.36133
4	1.38746
5	1.39995

95. **$CoBr_2$** (86)

0.5	1.34242
1	1.35149
2	1.36925
4	1.40383

96. **$CoSO_4$** (17); *see also* 581, 592

g B/kg A	n_D^{20}	α^*
3.1	1.3360	1.0_7
7.6	1.3366	1.0_7
15.3	1.3380	1.0_7

* If 15° < t < 30°C.

97. **$Co(NO_3)_2$** (86); *see also* 580.1, 592

N_{18}	n_D^{18}
0.5	1.34030
1	1.34706
2	1.36029
4	1.38565
5	1.39795

g B/kg A	n_D^{20} (17)	α^*
3.5	1.3362	1.0_0
9.0	1.3368	1.0_0
17.9	1.3384	1.1_3

* If 15° < t < 30°C.

98. **$NiCl_2$** (86); *see also* 579, 593

N_{18}	n_D^{18}
0.5	1.34087
1	1.34823
2	1.36240
4	1.38962

98.—(*Continued*)

N_{18} (65)	n_{3256}^{18}
0.4960	1.36173
1.002	1.37005
2.037	1.38651
4.014	1.41655

g B/kg A	n_D^{20} (17)	α^*
2.6	1.3357	1.2_0
6.5	1.3367	1.0_0
13.1	1.3379	1.1_3

* If 15° < t < 30°C.

99. **$Ni(ClO_3)_2$** (86)

N_{18}	n_D^{18}
0.5	1.34086
1	1.34823
2	1.36255
4	1.38959

99.1. **$NiBr_2$** (86)

0.5	1.34280
1	1.35214
2	1.37053
4	1.40599

100. **$NiSO_4$** (17); *see also* 593

g B/kg A	n_D^{20}	α^*
3.2	1.3356	1.0_0
7.7	1.3364	1.0_0
15.5	1.3374	1.0_7

* If 15° < t < 30°C.

101. **$Ni(NO_3)_2$** (86); *see also* 593

N_{18}	n_D^{18}
0.5	1.34058
1	1.34763
2	1.36130
4	1.38743
6	1.41222

g B/kg A	n_D^{20} (17)	α^*
3.7	1.3358	1.1_3
9.2	1.3368	1.0_0
18.4	1.3381	1.2_0

* If 15° < t < 30°C.

101.1. **CrO_3** (113); *see also* 582

g B/l soln., 25°	n_D^{25}	d_4^{25}
3.5907_5	1.33382	1.00082

102. **$CrCl_3$** (86); *see also* 594

N_{18}	n_D^{18}
0.3	1.33784
0.5	1.34072
1	1.34790
2	1.36193

g B/kg A	n_D^{20} (17)	α^*
1.6	1.3355	1.0_7
3.2	1.3365	1.0_7
7.9	1.3391	1.3_3

* If 15° < t < 30°C.

103. **$CrBr_3$** (86)

N_{18}	n_D^{18}
0.5	1.34275
1	1.35194
2	1.37029

104. **$Cr_2(SO_4)_3$** (17); *see also* 594

g B/kg A	n_D^{20}	α^*
4.0	1.3349	1.0_0
8.0	1.3361	1.1_3
16.1	1.3370	1.0_7

* If 15° < t < 30°C.

105. **$Cr(NO_3)_3$** (17); *see also* 594

g B/kg A	n_D^{20}	α^*
2.4	1.3357	1.0_7
4.8	1.3368	1.0_7
11.9	1.3393	1.0_7

* If 15° < t < 30°C.

106. **$(NH_4)_2CrO_4$** (Abbe-Zeiss) (14)

N_{20}	n_D^{20}
0.1	1.3350
1	1.3532
1	n_D^{30} = 1.3522

107. **MoO_3** (113); *see also* 535, 547, 551, 553–555, 559–563, 565, 567–569, 582

g B/l soln., 25°	n_D^{25}	d_4^{25}
1.0030	1.33267	0.99781
1.3131	1.33272	0.99814
4.8034_5	1.33337	1.00119
5.4904_5	1.33347	1.00146
5.7626	1.33351	1.00186
9.4047	1.33426	1.00441
11.5253	1.33457	1.00660
11.8782	1.33472	1.00721
12.0676	1.33474	1.00708
12.0844	1.33514	1.00832
22.3675	1.33649	1.01554

108. **$(NH_4)_6Mo_7O_{24}$**, Crystallized twice (29); *see also* 564

g B/l soln.	n_D^t	t
10	1.3314	19.6
10	1.3316	20.6
25	1.3343	20.3
200	1.36519*	25

* d_4^{25} = 1.13560 (113).

109. **$UO_2(NO_3)_2$**, Anhydrous (149)

% B	n_D^{17}	d_{17}^{17}
2.80	1.33597	1.0257
5.73	1.33869	1.0510
10.92	1.34417	1.1035
14.26	1.34675	1.1288
16.96	1.35041	1.1625
20.05	1.35412	1.1983
25.58	1.36158	1.2599
29.77	1.36758	1.3247
34.88	1.37489	1.3939
37.85	1.37901	1.4295
39.73	1.38272	1.4669
43.11	1.38804	1.5204
44.02	1.38974	1.5275
47.94	1.39714	1.6155
49.92	1.39889	1.6506
52.04	1.40511	1.7118
53.91	1.40843	1.7480
54.77	1.41155	1.7536

109.1. **V_2O_5** (83)

110. **$AlCl_3$** (86)

N_{18}	n_D^{18}
0.5	1.33953
1	1.34568
2	1.35736
4	1.37981

111. **$Al_2(SO_4)_3$** (113); *see also* 545, 583

g B/l soln., 25°	n_D^{25}	d_4^{25}
68.475	1.34710	1.06880

112. **$Al(NO_3)_3$** (86)

N_{18}	n_D^{18}
0.5	1.33932
1	1.34522
2	1.35682
4	1.37887
6	1.39972

113. **$Al(CNS)_3$** (Kahlbaum) (35)

M_B/M_A	n_D^{18}	d_4^{18}
36.79	1.41207	1.1582

114. **$BeCl_2$**; t = 18°C (86)

N_t	n_D^t
0.5	1.33783
1	1.34234
2	1.35117
4	1.36857

115. **$Be(NO_3)_2$**; t = 18°C (86)

0.5	1.33772
1	1.34210
2	1.35082
4	1.36810

116. **$MgCl_2$**; t = 18°C (64)

0.1	1.33448
0.2	1.33567
0.5	1.33930
1.0	1.34511
2.0	1.35636
4.0	1.37751

117. **$MgCl_2.6H_2O$** (Abbe-Zeiss); t = 20°C (14)

0.1	1.3346
1	1.3451
1	n_D^{30} = 1.3442

118. **$Mg(ClO_3)_2$**; t = 18°C (64)

0.1	1.33452
0.2	1.33571
0.5	1.33831
1.0	1.34518
2.0	1.35649
4.0	1.33770

119. **$MgSO_4.7H_2O$** (Abbe-Zeiss); t = 20°C (14)

0.1	1.3344
1	1.3450
1	n_D^{30} = 1.3440

120. **$Mg(NO_3)_2$**; t = 18°C (64)

0.1	1.33443
0.2	1.33554
0.5	1.33891
1.0	1.34435
2.0	1.35504
4.0	1.37510

121. **$Mg(C_2H_3O_2)_2$**, Acetate; t = 18°C (64)

0.1	1.33461
0.2	1.33593
0.5	1.33977
1.0	1.34604

121.—(*Continued*)

N_t	n_D^t
2.0	1.35826
3.0	1.36995

N_{23}	n_D^{23} (47)	d_{23}^{23}
$\frac{1}{16}$	1.3333	1.0004
$\frac{1}{8}$	1.3340	1.0027
$\frac{1}{4}$	1.3355	1.0074
$\frac{1}{2}$	1.3386	1.0168
1	1.3448	1.0348

122. $MgCrO_4$; t = 18°C (86)

N_t	n_D^t
0.5	1.34421
1	1.35473
2	1.37525
4	1.41423
5	1.43295

123. $CaCl_2$ (Abbe-Zeiss); t = 20°C (14)

0.1	1.3346
1.0	1.3461
1	n_D^{30} = 1.3452

124. $Ca(ClO_3)_2$; t = 18°C (64)

0.5	1.33997
1.0	1.34647
2.0	1.35900
4.0	1.38255

125. $Ca(NO_3)_2$, Anhydrous; t = 18°C (64); *see also* 558

0.1	1.33454
0.2	1.33578
0.5	1.33947
1.0	1.34541
2.0	1.35677
4.0	1.37789
5.5	1.39257

t	d_4^t	n_D^t
0 % B		
15.0	0.9990	1.33351
17.5	86	329
20.0	81	304
22.5	76	278
25.0	70	257
27.5	63	233
30.0	56	203
32.5	48	181
35.0	40	149
4.38 % B		
15.0	1.0337	1.34153
17.5	331	126
20.0	324	104
22.5	317	076
25.0	309	041
27.5	301	010
30.0	291	1.33981
32.5	283	949
35.0	273	914
8.67% B		
15.0	1.0671	1.34915
17.5	662	882
20.0	653	848
22.5	644	822
25.0	634	779
27.5	624	740

125.—(*Continued*)

t	d_4^t	n_D^t
8.67% B.—(*Cont'd*)		
30.0	1.0614	1.34711
32.5	602	668
35.0	591	629
13.22% B		
15.0	1.1054	1.35768
17.5	042	729
20.0	032	697
22.5	021	665
25.0	009	629
27.5	1.0997	588
30.0	985	545
32.5	972	512
35.0	958	473
17.44% B		
15.0	1.1422	1.36570
17.5	402	534
20.0	396	493
22.5	383	449
25.0	371	408
27.5	357	366
30.0	344	323
32.5	330	277
35.0	315	239

126. $Ca(CNS)_2$ (Kahlbaum) (35)

M_B/M_A	d_4^{17}	n_D^{17}
17.55	1.2185	1.43356

127. $Ca(CHO_2)_2$, Formate; t = 20°C (47)

N_t	d_t^t	n_D^t
$\frac{1}{16}$	1.0022	1.3336
$\frac{1}{8}$	1.0052	1.3341
$\frac{1}{4}$	1.0109	1.3353
$\frac{1}{2}$	1.0220	1.3384

128. $Ca(C_2H_3O_2)_2.H_2O$, Acetate; t = 20°C (47)

$\frac{1}{16}$	1.0022	1.3341
$\frac{1}{8}$	1.0050	1.3358
$\frac{1}{4}$	1.0107	1.3376
$\frac{1}{2}$	1.0216	1.3408
1	1.0426	1.3471
2	1.0825	1.3585

129. $Ca(C_3H_5O_3)_2.3H_2O$, Lactate; t = 22.5°C (47)

$\frac{1}{16}$	1.0025	1.3339
$\frac{1}{8}$	1.0060	1.3350
$\frac{1}{4}$	1.0129	1.3374
$\frac{1}{2}$	1.0265	1.3416

130. $Ca(C_4H_7O_2)_2$, Isobutyrate; t = 22.5°C (47)

$\frac{1}{16}$	1.0017	1.3339
$\frac{1}{8}$	1.0044	1.3352
$\frac{1}{4}$	1.0100	1.3373
$\frac{1}{2}$	1.0208	1.3420
1	1.0414	1.3507

131. $SrCl_2$; t = 18°C (64)

N_t	n_D^t
0.1	1.33471
0.2	1.33613
0.5	1.34033
1.0	1.34711
2.0	1.36036

131.—(*Continued*)

N_t	n_D^t
4.0	1.38549
5.5	1.40352

132. $SrCl_2.6H_2O$ (Abbe-Zeiss); t = 20°C (14)

0.1	1.3350
1	1.3472
1	n_D^{30} = 1.3465

133. $Sr(ClO_3)_2$; t = 18°C (64)

0.1	1.33475
0.2	1.33618
0.5	1.34041
1.0	1.34730
2.0	1.36047
4.0	1.38516

134. $Sr(NO_3)_2$; t = 18°C (64)

0.1	1.33467
0.2	1.33599
0.5	1.33993
1.0	1.34625
2.0	1.35838
4.0	1.38075
t = 20°C (14)	
0.1	1.3350
1	1.3468
1	n_D^{30} = 1.3460

135. $Sr(C_2H_3O_2)_2$, Acetate; t = 18°C (64)

0.2	1.33636
0.5	1.34066
1.0	1.34778
2.0	1.36112
3.0	1.37355

N_{26} (47)	n_D^{26}	d_{26}^{26}
$\frac{1}{16}$	1.3331	1.0019
$\frac{1}{8}$	1.3341	1.0061
$\frac{1}{4}$	1.3361	1.0144
$\frac{1}{2}$	1.3396	1.0307
1	1.3463	1.0631

136. $BaCl_2$; t = 18°C (64)

N_t	n_D^t
0.1	1.33483
0.2	1.33634
0.5	1.34088
1.0	1.34831
2.0	1.36260
3.0	1.37643

137. $BaCl_2.2H_2O$ (Abbe-Zeiss); t = 20°C (14)

0.1	1.3350
1	1.3487
1	n_D^{30} = 1.3478

138. $Ba(ClO_3)_2$; t = 18°C (64)

0.5	1.34097
1.0	1.34831
2.0	1.36283

138.1. BaI_2; *see* 571

139. $Ba(CHO_2)_2$, Formate (47)

N_{23}	n_D^{23}	d_{23}^{23}
$\frac{1}{16}$	1.3336	1.0049
$\frac{1}{8}$	1.3345	1.0108
$\frac{1}{4}$	1.3362	1.0227
$\frac{1}{2}$	1.3396	1.0460
1	1.3466	1.0921

140. $Ba(C_2H_3O_2)_2$, Acetate (64)

N_{18}	n_D^{18}
0.2	1.33658
0.5	1.34136
1.0	1.34909
2.0	1.36397

141. $Ba(C_3H_5O_2)_2$, Propionate (47)

N_{23}	n_D^{23}	d_{23}^{23}
$\frac{1}{16}$	1.3344	1.0054
$\frac{1}{8}$	1.3355	1.0109
$\frac{1}{4}$	1.3379	1.0225
$\frac{1}{2}$	1.3425	1.0448

142. LiOH (Pulfrich) (18)

t	n_D^t
10.1 g B/l soln.	
20.0	1.3375
24.0	1.3374
30.0	1.3367
43.9	1.3346
50.5	1.3337
24.3 g B/l soln.	
21.0	1.3421
25.0	1.3416
38.0	1.3399
46.0	1.3386
44.6 g B/l soln.	
17.0	1.3504
21.0	1.3503
22.3	1.3502
30.0	1.3490
45.9	1.3468
98.2 g B/l soln.	
17.0	1.3682
21.0	1.3677
22.6	1.3675
42.0	1.3645
43.0	1.3643

143. LiCl (10)

% B	n_D^{25}	d_4^{25}
0.6254	1.33388	1.00068
0.6977	1.33405	1.00116
0.9329	1.33456	1.00240
0.9578	1.33446	1.00243
0.9688	1.33460	1.00271
1.4114	1.33555	1.00511
2.7648	1.33833	1.01308
2.7703	1.33842	1.01311
5.7352	1.34465	1.02966
6.5965	1.34653	1.03484
10.5860	1.35494	1.05832
13.1099	1.36024	1.07299

N_{18}	n_D^{18} (64)
0.5	1.33774
1.0	1.34207
2.0	1.35053
4.0	1.36651
t = 20°C (56)	
1	1.34174

% B	n_D^{25} (95)
0.00	1.3326
10.68	1.3565
15.27	1.3673

143.—(*Continued*)

% B	n_D^{25} (95)
21.10	1.3838
31.50	1.4069
36.36	1.4149
40.76	1.4289
43.33	1.4343

(Pulfrich) (18)

t	n_D^t
69.2 g B/l soln.	
17.0	1.3477
19.3	1.3475
20.1	1.3474
40.8	1.3456
53.0	1.3443
206.2 g B/l soln.	
17.0	1.3711
20.0	1.3708
34.0	1.3693
339.6 g B/l soln.	
18.0	1.3979
20.2	1.3977
29.0	1.3966
35.0	1.3960
49.0	1.3943
59.0	1.3930
604.0 g B/l soln.	
18.3	1.4373
20.1	1.4371
28.0	1.4357
46.0	1.4334

144. $LiCl.2H_2O$ (Abbe-Zeiss) (14)

N_{20}	n_D^{20}
0.1	1.3340
1.0	1.3420
1	n_D^{30} = 1.3410

145. $LiClO_3$ (65)

N_{18}	n_{3256}^{18}
0.5124	1.35825
1.023	1.36313
2.043	1.37211
4.090	1.39000

146. LiBr (10)

% B	n_D^{25}	d_4^{25}
0.1980	1.33273	0.9984
0.3328	1.33300	0.9995
0.3889	1.33307	0.9999
0.4313	1.33309	1.0001
0.8136	1.33369	1.0028
1.0244	1.33401	1.0044
1.4355	1.33466	1.00745
1.6802	1.33499	1.0092
1.8718	1.33530	1.0108
3.5637	1.33788	1.0233
3.5919	1.33793	1.0234
3.7527	1.33825	1.0245
4.2994	1.33905	1.0287
4.6222	1.33954	1.0309
6.1940	1.34200	1.04335
14.966	1.35662	1.1153
18.190	1.36254	1.1434
32.55	1.39194	1.2889

146.—(*Continued*)

N_{18}	n_D^{18} (64)
0.5	1.33969
1.0	1.34600
2.0	1.35833
4.0	1.38223

147. LiI (10)

% B	n_D^{25}	d_4^{25}
1.1083	1.33424	1.00509
1.4231	1.33468	1.00742
1.4512	1.33473	1.00755
2.1422	1.33580	1.01282
2.3577	1.33620	1.01438
2.5287	1.33641	1.01567
4.9689	1.34033	1.03405
12.3103	1.35311	1.09490
15.4751	1.35908	1.12291

N_{18}	n_D^{18} (64)
0.2	1.33740
0.5	1.34357
1.0	1.35283
2.0	1.37428
4.0	1.41506

148. $LiIO_3$ (64)

0.1	1.33575
0.2	1.33823
0.5	1.34559
1.0	1.35767
2.0	1.38105
3.0	1.40367

149. Li_2SO_4 (86)

N_{18}	n_D^{18}
0.5	1.33802
1	1.34247
2	1.35078
4	1.36544
5	1.37207

N_{18} (65)	n_{3256}^{18}
0.4307	1.35764
0.871	1.36175
1.744	1.36943
3.493	1.38324

150. $LiNO_3$; t = 18°C (64); *see also* 575

N_t	n_D^t
0.5	1.33644
1.0	1.33951
2.0	1.34555
4.0	1.35703
t = 20°C (56)	
0.5	1.33648
1.0	1.34123

If g B/l soln., 25° = 69.07, n_D^{25} = 1.33800, d_4^{25} = 1.02338 (113).

151. $LiC_2H_3O_2$, Acetate; t = 18°C (64)

0.1	1.33428
0.2	1.33528
0.5	1.33824
1.0	1.34312
2.0	1.35271
4.0	1.37119

151.—(*Continued*)

N_{18} (65)	n_{3256}^{18}
0.4885	1.35871
1.047	1.36479
2.022	1.37506
4.033	1.39620

152. LiCNS (65)

0.5109	1.36371
1.031	1.37427
2.082	1.39530
3.465	1.42285
N_{18}	n_D^{18} (64)
0.5	1.33971
1.0	1.34566
2.0	1.35781
3.0	1.36993

153. Li_2CrO_4 (86)

N_{18}	n_D^{18}
0.3	1.33916
0.5	1.34297
1	1.35242
2	1.37079
4	1.40591
(64)	
0.1	1.33529
0.2	1.33727
0.5	1.34307
1.0	1.35251
2.0	1.37095
4.0	1.40612

154. $Li_2Cr_2O_7$ (86)

0.3	1.34093
0.5	1.34603
1	1.35862

154.1. Na_2O; *see* 570

155. NaOH (28); *see also* 536, 538, 566

N_t	n_D^t	t
0.5	1.3380	21
2.0	1.3535	15

156. NaCl (10); *see also* 230, 584

% B	n_D^{25}	d_4^{25}
0.5280	1.33342	1.00079
0.5493	1.33341	1.00098
0.9980	1.33417	1.00413
1.0618	1.33433	1.00432
1.1068	1.33438	1.00477
5.3562	1.34169	1.03488
5.4131	1.34179	1.03532
14.344	1.35747	1.10146

(138)

% B	n_D^t
5	1.34172
10	1.35021
15	1.35893
20	1.36829

N_t	n_D^t
t = 18°C (64)	
0.5	1.33834
1.0	1.34318
2.0	1.35241
4.0	1.36959

156.—(*Continued*)

N_t	n_D^t
t = 22.7°C (13)	
¼	1.33400
½	1.33576
1	1.33929
t = 20°C (56)	
1	1.34277
t = 20°C (14)	
0.1	1.3341
1	1.3431
1	n_D^{30} = 1.3423

If g B/l soln., 25° = 58.5, n_D^{25} = 1.34223, d_4^{25} = 1.03704 (113).

157. $NaClO_3$; t = 18°C (64)

0.1	1.33431
0.2	1.33532
0.5	1.33833
1.0	1.34313
2.0	1.35229
4.0	1.36916

158. NaBr (10)

% B	n_D^{25}	d_4^{25}
0.4857	1.3311	1.00074
0.9110	1.33370	1.0041
1.1162	1.33402	1.0058
1.9817	1.33522	1.0123
2.1044	1.33535	1.01354
2.8104	1.33639	1.01931
2.9218	1.33649	1.0198
4.5543	1.33883	1.03268
4.6241	1.33890	1.03320
6.5288	1.34159	1.0490
7.2055	1.34257	1.0544
7.3936	1.34291	1.05600
8.8063	1.34501	1.06832
17.261	1.35822	1.14479
46.06	1.41841	1.5005

N_{18}	n_D^{18} (64)
0.5	1.34031
1.0	1.34718
2.0	1.36021
4.0	1.38611

159. NaI (10)

% B	n_D^{25}	d_4^{25}
0.5723	1.33333	1.00154
0.7125	1.33352	1.00258
0.7137	1.33353	1.00261
0.7469	1.33362	1.00294
3.7111	1.33793	1.02588
3.8603	1.33817	1.02716
6.8272	1.34278	1.05152
18.4384	1.36281	1.15808
30.418	1.38783	1.29156

N_{18}	n_D^{18} (64)
0.5	1.34411
1.0	1.35476
2.0	1.37585
4.0	1.41763

160. Na_2SO_4 (35), Best commercial salt

M_B/M_A	n_D^t	d_4^t	t
74.9	1.34745*	1.0880	15
74.9	1.34771†	1.0884	13.5
72.4	1.34694‡	1.0872	15
71.2	1.34855‡	1.0938	13.5
65.8	1.34783†	1.0984	17

* Ignited in Pt.

† Dried at 100°.

‡ Recrystallized from H_2O, air-dried.

161. $NaNO_3$; t = 18°C (64)

N_t	n_D^t
0.1	1.33427
0.2	1.33522
0.5	1.33802
1.0	1.34250
2.0	1.35086
4.0	1.36622

t = 20°C (56)

0.5	1.33751
1	1.34174

(Abbe-Zeiss) t = 20°C (14)

0.1	1.3341
1	1.3420
1	n_D^{30} = 1.3411

162. NaN_3 (Pulfrich) (19)

g B/l soln.	n_D^t	t
100	1.35226	15
	1.35144	20.0
	1.35071	24.5
	α = 1.63	
200	1.36953	15.8
	1.36883	20.0
	1.36808	24.5
	α = 1.66	
300	1.38622	16.6
	1.38549	20.0
	1.38527	21
	α = 2.16	
340	1.39296	15.7
	1.39189	20.0
	1.39102	23.5
	α = 2.49	

163. $Na_2C_2O_4$, Oxalate; t = 19.5°C (47)

N_t	n_D^t	d_t^t
$\frac{1}{16}$	1.3340	1.0031
$\frac{1}{8}$	1.3347	1.0065
$\frac{1}{4}$	1.3360	1.0132
$\frac{1}{2}$	1.3388	1.0269

164. $NaCHO_2$, Formate (47)

$N_{20.5}$	$n_D^{20.5}$	$d_{20.5}^{20.5}$
$\frac{1}{16}$	1.3334	1.0016
$\frac{1}{8}$	1.3337	1.0044
$\frac{1}{4}$	1.3345	1.0092
$\frac{1}{2}$	1.3365	1.0192
1	1.3401	1.0387
2	1.3470	1.0769
4	1.3593	1.1490

165. $NaHCO_3$ (Abbe-Zeiss) t = 20°C (14)

N_t	n_D^t
0.1	1.3341
1	1.3441
1	n_D^{30} = 1.3432

166. $NaC_2H_3O_2$, Acetate; t = 18°C (64); *see also* 255

0.1	1.33442
0.5	1.33883
1.0	1.34414
2.0	1.35423
4.0	1.37298

% B	n_D^{25} (84)	d_0^{25}
0	1.33253	0.9969
5	1.33463	1.013

167. $NaC_2H_3O_2.3H_2O$, Acetate (47)

N_{20}	n_D^{20}	d_{20}^{20}
$\frac{1}{16}$	1.3333	1.0012
$\frac{1}{8}$	1.3340	1.0038
$\frac{1}{4}$	1.3353	1.0086
$\frac{1}{2}$	1.3378	1.0181
1	1.3428	1.0367
2	1.3526	1.0725
4	1.3706	1.1406

168. $NaC_3H_5O_2$, Propionate; t = 20°C (47); *see also* 258

N_t	n_D^t	d_t^t
$\frac{1}{16}$	1.3335	1.0011
$\frac{1}{8}$	1.3343	1.0034
$\frac{1}{4}$	1.3360	1.0079
$\frac{1}{2}$	1.3392	1.0170
1	1.3455	1.0347
2	1.3580	1.0689
4	1.3805	1.1324

169. $NaHC_4H_4O_6$, Acid tartrate; t = 19.5°C (47)

$\frac{1}{16}$	1.3342	1.0031
$\frac{1}{8}$	1.3351	1.0063
$\frac{1}{4}$	1.3366	1.0127
$\frac{1}{2}$	1.3396	1.0250
1	1.3454	1.0496

170. $NaC_4H_7O_2$, Butyrate; t = 20.5°C (47); *see also* 261

$\frac{1}{16}$	1.3339	1.0015
$\frac{1}{8}$	1.3350	1.0039
$\frac{1}{4}$	1.3372	1.0081
$\frac{1}{2}$	1.3410	1.0170
1	1.3485	1.0341
2	1.3633	1.0670
4	1.3889	1.1202

% B	n_D^{25} (84)	d_0^{25}
0	1.33253	0.9969
5	1.33470	1.014

171. $NaC_4H_7O_2$, Isobutyrate; t = 22.5°C (47)

N_t	n_D^t	d_t^t
$\frac{1}{16}$	1.3338	1.0013
$\frac{1}{8}$	1.3348	1.0039
$\frac{1}{4}$	1.3371	1.0091
$\frac{1}{2}$	1.3410	1.0189
1	1.3492	1.0383
2	1.3650	1.0766
4	1.3916	1.1388

171.1. $NaC_5H_9O_2$, Valerate; *see* 265

172. $NaC_5H_9O_2$, Isovalerate; t = 22.5°C (47)

N_t	n_D^t	d_t^t
$\frac{1}{16}$	1.3339	1.0009
$\frac{1}{8}$	1.3351	1.0030
$\frac{1}{4}$	1.3373	1.0073
$\frac{1}{2}$	1.3417	1.0162
1	1.3506	1.0331
2	1.3677	1.0632
4	1.4000	1.1052

172.1. $NaC_7H_4NO_4$, *o*-Nitrobenzoate; *see* 286

172.2. $NaC_7H_4NO_4$, *m*-Nitrobenzoate; *see* 287

172.3. $NaC_7H_4NO_4$, *p*-Nitrobenzoate; *see* 288

173. $NaC_7H_5O_2$, Benzoate; t = 20°C (47); *see also* 294

N_t	n_D^t	d_t^t
$\frac{1}{16}$	1.3351	1.0033
$\frac{1}{8}$	1.3374	1.0071
$\frac{1}{4}$	1.3416	1.0152
$\frac{1}{2}$	1.3504	1.0303
1	1.3662	1.0602
2	1.3981	1.1169

174. $NaC_7H_5O_3$, Salicylate; t = 19°C (47)

$\frac{1}{16}$	1.3352	1.0045
$\frac{1}{8}$	1.3375	1.0090
$\frac{1}{4}$	1.3421	1.0183
$\frac{1}{2}$	1.3512	1.0368
1	1.3687	1.0728
2	1.4035	1.1425

175. $NaC_7H_5O_3$, *m*-Hydroxybenzoate; t = 23°C (47)

$\frac{1}{16}$	1.3352	1.0033
$\frac{1}{8}$	1.3370	1.0079
$\frac{1}{4}$	1.3411	1.0168
$\frac{1}{2}$	1.3501	1.0336

176. $NaC_8H_7O_2$, *o*-Toluate t = 24°C (47)

$\frac{1}{16}$	1.3349	1.0019
$\frac{1}{8}$	1.3370	1.0056
$\frac{1}{4}$	1.3412	1.0130
$\frac{1}{2}$	1.3505	1.0278
1	1.3701	1.0563

177. $NaC_8H_7O_2$, *m*-Toluate t = 24°C (47)

$\frac{1}{16}$	1.3341	1.0026
$\frac{1}{8}$	1.3350	1.0060
$\frac{1}{4}$	1.3372	1.0132
$\frac{1}{2}$	1.3491	1.0267
1	1.3647	1.0527

178. $NaC_8H_7O_2$, *p*-Toluate t = 24°C (47)

$\frac{1}{16}$	1.3346	1.0024
$\frac{1}{8}$	1.3367	1.0068
$\frac{1}{4}$	1.3409	1.0154
$\frac{1}{2}$	1.3493	1.0323

179. $NaC_8H_{15}O_2$, *n*-Octoate t = 22°C (47)

$\frac{1}{4}$	1.3390	1.0042
1	1.3566	1.0174

180. $NaC_{10}H_{19}O_2$, *n*-Decoate; t = 25.5°C (47)

N_t	n_D^t	d_t^t
$\frac{1}{16}$	1.3348	1.0012
$\frac{1}{8}$	1.3363	1.0023
$\frac{1}{4}$	1.3397	1.0056
$\frac{1}{2}$	1.3465	1.0122
1	1.3603	1.0234

181. $NaC_{16}H_{31}O_2$, Palmitate (85); *see also* 341

g B/l soln., 70°	n_D^{70}
Pure; from pure acid and alkali	
30.4	1.32935
40.7	1.33078
51.9	1.33223
62.3	1.33362
Purified commercial material	
28.9	1.32935
33.7	1.33050
45.2	1.33147
52.3	1.33293
64.7	1.33455
72.1	1.33549
86.8	1.33777

182. $NaC_{18}H_{33}O_2$, Oleate (85); *see also* 344

Pure; from pure acid and alkali

38.8	1.33078
49.7	1.33223
69.2	1.33503
100.4	1.33985
126.8	1.34351
149.0	1.34715
177.5	1.35122

183. $NaC_{18}H_{35}O_2$, Stearate (85)

Purified commercial material

24.2	1.32855
28.4	1.32921
35.7	1.33042
44.9	1.33132

For the above and other soaps, *see also* Vol. V, p. 456, 458.

184. $Na_2C_4H_4O_4$, Succinate

t = 22°C (47)

N_t	n_D^t	d_t^t
$\frac{1}{16}$	1.3335	1.0020
$\frac{1}{8}$	1.3343	1.0051
$\frac{1}{4}$	1.3360	1.0111
$\frac{1}{2}$	1.3389	1.0231
1	1.3452	1.0465
2	1.3568	1.0915
4	1.3791	1.1772

185. $Na_2C_4H_4O_6$, Tartrate t = 19°C (47)

$\frac{1}{16}$	1.3343	1.0036
$\frac{1}{8}$	1.3352	1.0072
$\frac{1}{4}$	1.3368	1.0144
$\frac{1}{2}$	1.3400	1.0284
1	1.3462	1.0561
2	1.3578	1.1094
4	1.3797	1.2115

186. **$Na_2C_8H_4O_4$**, Phthalate

N_t	n_D^t	d_t^t
t = 23°C (47)		
$\frac{1}{16}$	1.3343	1.0024
$\frac{1}{8}$	1.3359	1.0063
$\frac{1}{4}$	1.3384	1.0139
$\frac{1}{2}$	1.3440	1.0286
1	1.3548	1.0576

187. **$Na_2C_8H_4O_4$**, Isophthalate

t = 23°C (47)

$\frac{1}{16}$	1.3341	1.0019
$\frac{1}{8}$	1.3355	1.0056
$\frac{1}{4}$	1.3382	1.0123
$\frac{1}{2}$	1.3436	1.0256
1	1.3542	1.0523
2	1.3747	1.1041

188. **$Na(C_2H_5)SO_4$**, Ethylsulfate, best commercial material (35)

M_B/M_A	n_D^t	d_4^t	t
17.40	1.36387*	1.1689	14
16.71	1.36360†	1.1699	12.5
12.39	1.37431	1.2380	13.5

* Recrystallized from C_2H_5OH, dried at 100°C.

† Recrystallized from C_2H_5OH, air-dried.

188.1. **$NaC_7H_5N_2O_4$**, *p*-Nitrophenylnitromethane; *see* 293

189. **NaCNS** (64)

N_{18}	n_D^{18}
0.5	1.33990
1.0	1.34642
2.0	1.35927
4.0	1.38387

M_B/M_A	n_D^{18} (35)	d_4^{18}
11.27	1.40250*	1.1600
6.66	1.43336*	1.2306
5.66	1.44461†	1.2599

* Crystallized from 96 % C_2H_5OH.

† Kahlbaum's material.

190. **Na_2SiO_3** (64); *see also* 570

N_{18}	n_D^{18}
0.1	1.33474
0.2	1.33615
0.5	1.34019
1.0	1.34657
2.0	1.35859
4.0	1.38011

191. **Na_2CrO_4** (86)

0.3	1.33941
0.5	1.34342
1	1.35329
2	1.37234

192. **KOH** (28); *see also* 539, 548–550

N_t	n_D^t	t
1.0	1.3439	15
1.0	1.3427	25
2.0	1.3538	12*
2.0	1.3530	17.5

* t = 12 to 12.5°C.

193. **KCl** (10); *see also* 230, 572, 584

% B	n_D^{25}	d_4^{25}
0.9466	1.33376	1.00303
0.9716	1.33380	1.0031
0.9769	1.33380	1.0032
0.9983	1.33382	1.0033
1.0013	1.33388	1.0036
2.4297	1.33577	1.0122
2.4623	1.33581	1.0124
4.6474	1.33871	1.02654
4.8150	1.33896	1.0285
4.8318	1.33896	1.0281
4.8340	1.33896	1.0282
7.1573	1.34215	1.0428
7.1699	1.34215	1.0430
9.0221	1.34463	1.0549
9.4153	1.34517	1.0577
9.5004	1.34528	1.05814
13.758	1.35122	1.0865
17.852	1.35678	1.1155
17.898	1.35687	1.1160
21.522	1.36202	1.1426
21.770	1.36238	1.1441

(138)

% B	n_D^{25}
5	1.33931
10	1.34643
15	1.35035
20	1.35992

If g B/l soln., 25° = 74.6, n_D^{25} = 1.34208, d_4^{25} = 1.04296 (113).

t = 18°C (64)

N_t	n_D^t
0.1	1.33423
0.2*	1.33525
0.5	1.33825
1.0	1.34299
2.0	1.35215
3.0	1.36053
t = 20°C (56)	
1	1.34260
(Abbe) t = 20°C (14)	
0.1	1.3341†
1	1.3428‡
2	1.3518
3	1.3603

* n_D^{18} = 1.33513 (148).

† n^{30} = 1.3329.

‡ n^{30} = 1.3420.

194. **KBr** (10)

% B	n_D^{25}	d_4^{25}
0.3786	1.33292	0.99971
0.9874	1.33370	1.00396
1.4297	1.33408	1.00718
1.4978	1.33425	1.00776
2.9364	1.33596	1.01829
3.6692	1.33684	1.02373
4.1387	1.33743	1.02704
4.2164	1.33749	1.02770
4.2999	1.33763	1.02821
4.4552	1.33777	1.02941
7.1636	1.34115	1.05006

194.—(*Continued*)

% B	n_D^{25}	d_4^{25}
7.8856	1.34200	1.05543
8.8542	1.34327	1.06317
9.7228	1.34435	1.06977
10.7476	1.34575	1.07881
21.017	1.35984	1.16718

N_t	n_D^t
t = 18°C (64)	
0.5	1.34011
1.0	1.34658
2.0	1.35967
4.0	1.38409
(Abbe-Zeiss) t = 20°C (14)	
0.1	1.3345
1	1.3470
1	n_D^{30} = 1.3461

195. **KI** (10); *see also* 573, 585

% B	n_D^{25}	d_4^{25}
0.4379	1.33306	1.00045
0.9151	1.33367	1.00382
1.2259	1.33409	1.00601
2.3607	1.33554	1.01419
3.1122	1.33658	1.01986
5.1029	1.33927	1.03515
8.5864	1.34422	1.06282
25.604	1.37194	1.2200

N_t	n_D^t
t = 18°C (64)	
0.5	1.34411
1.0	1.35484
2.0	1.37581
4.0	1.41599
(Abbe-Zeiss) t = 20°C (14)	
0.1	1.3351
1	1.3540
1	n_D^{30} = 1.3530

If g B/l soln. = 33.10, n_D^{25} = 1.33676, d_4^{25} = 1.02093 (113).

196. **$KHSO_4$** (Abbe-Zeiss); t = 20°C (14)

0.1	1.3349
1	1.3465
1	n_D^{30} = 1.3455

197. **K_2SO_4** (35); Best commercial material; *see also* 546, 583

M_B/M_A	n_D^t	d_4^t	t
107.4	1.34372*	1.0705	14
100.53	1.34402†	1.0718	14
100.0	1.34344†	1.0715	17
100.0	1.34394	1.0727	11
99.39	1.34394	1.0735	10
99.2	1.34361‡	1.0724	15.5
90.9	1.34436	1.0779	14

(Abbe-Zeiss) t = 20°C (14)

N_{20}	n_D^{20}
0.1	1.3341
1.0	1.3432
1	n_D^{30} = 1.3422

197.—(*Continued*)

If g B/l soln., 25° = 33.872, n_D^{25} = 1.33661, d_4^{25} = 1.02437 (113).

* Recrystallized from H_2O.

† Recrystallized from H_2O, dried at 100°C.

‡ Not recrystallized, dried at 100°C.

198. **KN_3** (Pulfrich) (19)

g B/l soln.	n_D^t	t
100	1.34825	16.5
	1.34774*	20.0
	1.34731	23.0
	α = 1.45	
200	1.36220	17.1
	1.36174*	20.0
	1.36148	21.6
	α = 1.6	
300	1.37620	15.5
	1.37527*	20.0
	1.37480	22.3
	α = 2.06	
360	1.38385	15.5
	1.38291*	20.0
	1.38208	24
	α = 2.08	

* Interpolated.

199. **KNO_3**; t = 18°C (64)

N_t	n_D^t
0.1	1.33426
0.2	1.33520
0.5	1.33801
1.0	1.34244
2.0	1.35066
t = 20°C (56)	
0.5	1.33743
1.0	1.34182
(Abbe-Zeiss) t = 20°C (14)	
0.1	1.3341
1	1.3419
1	n_D^{30} = 1.3410

200. **K_2CO_3** (Abbe-Zeiss); t = 20°C (14)

0.1	1.3341
1	1.3441
1	n_D^{30} = 1.3431

201. **$K_2C_2O_4$**, Oxalate (47)

N_{17}	n_D^{17}	d_{17}^{17}
$\frac{1}{16}$	1.3344	1.0034
$\frac{1}{8}$	1.3349	1.0070
$\frac{1}{4}$	1.3361	1.0145
$\frac{1}{2}$	1.3395	1.0293
1	1.3442	1.0576
2	1.3543	1.1129

M_B/M_A	n_D^t (35)	d_4^t	t
54.30	1.35344	1.1111	13.5
27.77	1.36723*	1.1972	17

* Recrystallized from dilute C_2H_5-OH.

202. **$KHCO_3$** (Abbe-Zeiss) (14)

N_{20}	n_D^{20}
0.1	1.3341
1	1.3440
1	n_D^{30} = 1.3431

203. $\mathbf{KCHO_2}$, Formate

N_t	n_D^t	d_t^t
	t = 21°C (47)	
$\frac{1}{16}$	1.3331	1.0023
$\frac{1}{8}$	1.33371	1.0053
$\frac{1}{4}$	1.3349	1.0112
$\frac{1}{2}$	1.3371	1.0243
1	1.3409	1.0461
2	1.3491	1.0909
4	1.3601	1.1763

204. $\mathbf{KC_2H_3O_2}$, Acetate; t = 18°C (64)

N_{18}	n_D^{18}
0.1	1.33444
0.2	1.33555
0.5	1.33888
1.0	1.34439
2.0	1.35487
4.0	1.37402

N_t	n_D^t (47)	d_t^t
$\frac{1}{16}$	1.3340	1.0027
$\frac{1}{8}$	1.3346	1.0054
$\frac{1}{4}$	1.3361	1.0108
$\frac{1}{2}$	1.3389	1.0214
1	1.3439	1.0424
2	1.3537	1.0830
4	1.3730	1.1609

205. $\mathbf{KC_3H_5O_2}$, Propionate

t = 20°C (47)

$\frac{1}{16}$	1.3340	1.0019
$\frac{1}{8}$	1.3348	1.0048
$\frac{1}{4}$	1.3364	1.0103
$\frac{1}{2}$	1.3396	1.0215
1	1.3464	1.0438
2	1.3592	1.0866
4	1.3785	1.1443

206. $\mathbf{KC_4H_7O_2}$, Butyrate

t = 20°C (47)

$\frac{1}{16}$	1.3336	1.0023
$\frac{1}{8}$	1.3350	1.0051
$\frac{1}{4}$	1.3371	1.0106
$\frac{1}{2}$	1.3411	1.0219
1	1.3489	1.0439
2	1.3641	1.0864
4	1.3904	1.1579

207. $\mathbf{KC_4H_7O_2}$, Isobutyrate

t = 25°C (47)

$\frac{1}{16}$	1.3336	1.0011
$\frac{1}{8}$	1.3346	1.0042
$\frac{1}{4}$	1.3366	1.0100
$\frac{1}{2}$	1.3408	1.0218
1	1.3485	1.0448
2	1.3640	1.0890
4	1.3909	1.1678

208. $\mathbf{KC_7H_5O_2}$, Benzoate

t = 18.5°C (47)

$\frac{1}{16}$	1.3350	1.0037
$\frac{1}{8}$	1.3368	1.0078
$\frac{1}{4}$	1.3408	1.0159
$\frac{1}{2}$	1.3490	1.0322

209. $\mathbf{KC_{16}H_{31}O_2}$, Palmitate (85); *see also* 340 and Vol. V, p. 456, 458

Purified commercial material

g B/l soln., 70°	n_D^{70}
33	1.32935
38.2	1.33034
47.3	1.33162
56.2	1.33277
66.3	1.33424
75.7	1.33564
91.5	1.33762

210. $\mathbf{K_2C_4H_4O_4}$, Succinate

N_t	n_D^t	d_t^t
	t = 19°C (47)	
$\frac{1}{16}$	1.3337	1.0030
$\frac{1}{8}$	1.3345	1.0062
$\frac{1}{4}$	1.3361	1.0129
$\frac{1}{2}$	1.3393	1.0260
1	1.3460	1.0516
2	1.3579	1.1035
4	1.3800	1.2003

211. $\mathbf{K_2C_4H_4O_6}$, Tartrate

t = 18°C (47)

$\frac{1}{16}$	1.3341	1.0044
$\frac{1}{8}$	1.3350	1.0090
$\frac{1}{4}$	1.3372	1.0179
$\frac{1}{2}$	1.3408	1.0359
1	1.3485	1.0707
2	1.3625	1.1379
4	1.3913	1.2665

212. $\mathbf{K_3C_6H_5O_7}$, Citrate

t = 16.5°C (47)

$\frac{1}{16}$	1.3340	1.0041
$\frac{1}{8}$	1.3350	1.0082
$\frac{1}{4}$	1.3370	1.0166
$\frac{1}{2}$	1.3410	1.0331
1	1.3478	1.0650
2	1.3618	1.1293
4	1.3867	1.2452

213. $\mathbf{K(CH_3)SO_4}$, Methylsulfate (35); best commercial material

M_B/M_A	$n_D^{13.5}$	$d_4^{13.5}$
9.86	1.36905	1.2914

214. $\mathbf{K(C_2H_5)SO_4}$, Ethylsulfate (35); best commercial material

M_B/M_A	n_D^t	d_4^t	t
14.50	1.36632*	1.2033	12
12.17	1.36960	1.2315	14
12.17	1.37024	1.2315	13

* Recrystallized from C_2H_5OH; air-dried.

214.1 $\mathbf{KC_6H_5O_3S}$, Benzenesulfonate; *see* 280

215. $\mathbf{KCN}$ (113); *see also* 574, 576, 585

g B/l soln., 25°	n_D^{25}	d_4^{25}
13.036	1.33386	1.00350
13.038	1.33386	1.00346
65.19	1.34039	1.03153

215.1. $\mathbf{KC_6H_4NO_3}$, *o*-Nitrophenolate; *see* 272

215.2. $\mathbf{KC_6H_4NO_3}$, *m*-Nitrophenolate; *see* 273

215.3. $\mathbf{KC_6H_4NO_3}$, *p*-Nitrophenolate; *see* 274

215.4. $\mathbf{KC_6H_3N_2O_5}$, 2, 3-Dinitrophenolate; *see* 267

215.5. $\mathbf{KC_6H_3N_2O_5}$, 2. 4-Dinitrophenolate; *see* 268

215.6. $\mathbf{KC_6H_3N_2O_5}$, 2, 6-Dinitrophenolate; *see* 269

215.7. $\mathbf{KC_6H_3N_2O_5}$, 3, 4-Dinitrophenolate; *see* 270

215.8. $\mathbf{KC_6H_3N_2O_5}$, 3, 6-Dinitrophenolate; *see* 271

215.9. $\mathbf{KC_7H_5N_2O_4}$, *aci*-Phenylnitromethane; *see* 289

216. $\mathbf{KCNS}$; t = 18°C(64)

N_t	n_D^t
0.1	1.33508
0.2	1.33681
0.5	1.34204
1.0	1.35069
2.0	1.36780
4.0	1.40018
(Abbe-Zeiss) t = 20°C (14)	
0.1	1.3349
1	1.3511
1	n_D^{30} = 1.3502

217. $\mathbf{K_3Fe(CN)_6}$; t = 18°C (86)

0.5	1.34211
1	1.35071
2	1.36730

218. $\mathbf{K_4Fe(CN)_6}$; t = 18°C (86)

0.5	1.34253
1	1.35143
2	1.36874

219. $\mathbf{K_2CrO_4}$; t = 18°C (64)

0.1	1.33529
0.2	1.33732
0.5	1.34335
1.0	1.35305
2.0	1.37188
4.0	1.40709
t = 18°C (86)	
0.3	1.33929
0.5	1.34332
1	1.35305
2	1.37181
4	1.40661
(Abbe-Zeiss) t = 20°C (14)	
0.1	1.3350
1	1.3521
1	n_D^{30} = 1.3512

220. $\mathbf{K_2Cr_2O_7}$; t = 18°C (86)

0.3	1.34107
0.5	1.34628

221. $\mathbf{RbCl}$; t = 18°C (64)

N_t	n_D^t
0.1	1.33439
0.2	1.33550
0.5	1.33873
1.0	1.34398
2.0	1.35383
4.0	1.37265

For 1N; n_D^{20} = 1.34337 (56).

222. $\mathbf{RbBr}$; t = 18°C (64)

0.1	1.33476
0.2	1.33624
0.5	1.34064
1.0	1.34784
2.0	1.36177
4 0	1.38840

223. $\mathbf{RbI}$; t = 18°C (64)

0.2	1.33771
0 5	1.34450
1.0	1.35538
2.0	1.37721
4.0	1.41904

224. $\mathbf{Rb_2SO_4}$; t = 18°C (64)

0 1	1.33453
0 2	1.33575
0 5	1.33925
1 0	1.34472
2 0	1.35482
3.0	1.36377

225. $\mathbf{RbNO_3}$; t = 18°C (64)

0.1	1.33435
0 2	1.33542
0.5	1.33855
1.0	1.34360
2.0	1.35308
3.0	1.36216
t = 20°C (56)	
0.5	1.33785
1.0	1.34268

226. $\mathbf{CsCl}$; t = 18°C (64)

0.5	1.33986
1.0	1.34623
2 0	1.35853
4 0	1.38187

For 1N, n_D^{20} = 1.34571 (56).

227. $\mathbf{CsBr}$; t = 18°C (86)

0.5	1.34194
1	1.35042
2	1.36717
4	1.39909

228. $\mathbf{CsNO_3}$; t = 18°C (86)

0.3	1.33707
0.5	1.33953
1	1.34547
t = 20°C (56)	
0.5	1.33902
1.0	1.34492

228.1. **Gelatin** (83); 3.2% B

t	n_D^t	d_4^t
20	1.33749	1.006
30	1.33616	1.005
40	1.33488	1.003
50	1.33410	1.002
60	1.33298	1.000

Proteins; *see* Table 4

Non-Aqueous Two-Component Systems—Inorganic

S

229. B = **Se** (88)
Room temp.

% B	n_D
0.0	1.998
9.0	2.022
17.6	2.050
25.0	2.078
31.8	2.107
37.5	2.134
43.2	2.163
48.2	2.193
53.0	2.220
57.0	2.248
64.0	2.307
70.0	2.365
75.0	2.423
80.0	2.490
87.7	2.624
93.8	2.755

229.—(*Continued*)

% B	n_D
99.2	2.90
100	2.92

NaCl

230. B = **KCl** (96)
(Abbe) t = 18.0 ± 0.1°C

% A	n_D^{18}
0	1.490_3
10	1.495_5
20	1.500_0
30	1.504_8
40	1.509_3
50	1.514_5
60	1.520_5
70	1.525_8
80	1.531_6
90	1.538_2
100	1.544_3

Non-Aqueous Two-Component Systems

The A-Component is a C-Compound

C-Arrangement, *v.* Vol. III, p. viii

All carbon compounds containing no element of key-number greater than 16 are here indexed as A-components. For others, *see* Section I.

CCl_4

Carbon tetrachloride; *cf.* (130)

231. B = **$C_2H_4Br_2$**, Ethylene bromide; t = 25°C (129)

% A	n_D^t
0.00	1.5363
10.62	1.5261
20.27	1.5161
29.86	1.5076
39.85	1.4989
49.90	1.4909
60.02	1.4832
70.64	1.4763
80.02	1.4694
90.13	1.4634

232. B = **$C_2H_4O_2$**, Acetic acid (137)

t	n_D^t	$d_4^{t'}$	t'
21.319% A			
13.0	1.38524	1.13292	14.6
24.5	1.38050	1.12456	21.1
40.3	1.37340	1.11416	29.2
41.728% A			
13.3	1.39829	1.22167	14.2
39.5	1.38572	1.21144	21.3
57.0	1.37708	1.19884	29.3
64.436% A			
14.5	1.41676	1.33894	16.4
22.5	1.41277	1.32430	24.2
34.1	1.40660	1.31563	30.4

232.—(*Continued*)

t	n_D^t	$d_4^{t'}$	t'
100.000% A			
10.7	1.46563	1.60012	17.0
23.8	1.45786	1.58622	24.1
37.1	1.44989	1.57358	30.5

233. B = **C_2H_5I**, Ethyl iodide; t = 25.2°C (152)

% B	n_D^t
0.00	1.45707
12.78	1.46385
21.16	1.46782
29.35	1.47102
40.29	1.47755
49.35	1.48239
60.77	1.48858
70.15	1.49375
80.03	1.49901
90.23	1.50469
100.00	1.51009

234. B = **$C_4H_8O_2$**, Ethyl acetate; t = 25.2°C (152)

% B	n_D^t
0.00	1.45707
9.74	1.44305
20.10	1.43026
29.81	1.41936
39.99	1.40948
59.68	1.39362
69.44	1.38698
79.45	1.38082
89.98	1.37524
100.00	1.37012

235. B = **C_6H_6**, Benzene

% A	n_D^t
t = 18°C (80)	
0	1.5024
10	1.5008
20	1.4985
30	1.4958
40	1.4929
50	1.4894
60	1.4853
70	1.4807
80	1.4755
90	1.4692
100	1.4618
t = 25°C (70)	
0.000	1.49794
16.873	1.49420
31.954	1.49030
43.419	1.48674
55.495	1.48232
64.704	1.47849
71.042	1.47555
79.671	1.47109
87.639	1.46629
93.504	1.46230
100.000	1.45732

236. B = **C_7H_8**, Toluene

t = 18°C (80)	
0	1.4970
10	1.4965
20	1.4937
30	1.4914
40	1.4889
50	1.4860
60	1.4827
70	1.4787
80	1.4742
90	1.4685
100	1.4618
t = 25°C (129)	
0.00	1.4929
9.66	1.4912
20.00	1.4891
31.21	1.4869
39.88	1.4849
49.88	1.4817
60.29	1.4785
69.94	1.4743
80.04	1.4698
89.89	1.4641
100.00	1.4575

See also 586.

CS_2

Carbon disulfide; *cf.* (42, 154)

237. B = **$SnCl_4$**, Stannic chloride (135)

t	n_{5876}^t	$d_4^{t'}$	t'
0.00% B			
19.1	1.62783	1.26037	21.2
28.3	1.62070	1.24069	34.2
13.8282% B			
25.7	1.61160	1.33067	25.9
34.1	1.60476	1.31700	34.5

237.—(*Continued*)

t	n_{5876}^t	$d_4^{t'}$	t
27.2410% B			
24.9	1.59953	1.41697	25.2
34.1	1.59259	1.40184	34.2
38.6050% B			
23.7	1.58898	1.50003	24.5
34.1	1.58092	1.48290	34.3
44.3085% B			
24.2	1.58234	1.54270	25.9
36.1	1.57346	1.52696	34.4
66.3864% B			
26.2	1.55535	1.74819	26.5
35.5	1.54852	1.73114	34.6
80.7152% B			
25.1	1.53690	1.91772	25.1
37.4	1.52862	1.89828	34.5
100.00% B			
27.1	1.50751	2.21355	23.3
42.7	1.49795	2.12436	58.0

238. B = **$CHCl_3$**, Chloroform (135)

t	n_{5876}^t	$d_4^{t'}$	t'
0.000% B			
19.1	1.62783	1.26037	21.0
28.3	1.62070	1.24069	34.2
19.1533% B			
27.8	1.58706	1.27966	29.1
35.7	1.58148	1.27344	33.9
34.8063% B			
26.6	1.55971	1.31066	27.7
33.1	1.55457	1.30240	33.0
50.6210% B			
26.1	1.53157	1.34150	27.7
36.4	1.52391	1.33358	33.8
58.9405% B			
26.0	1.51669	1.35928	27.8
36.5	1.50874	1.34857	33.9
75.7576% B			
28.5	1.48382	1.39727	29.0
33.8	1.47992	1.38919	33.3
100.000% B			
22.7	1.44320	1.47571	22.0
35.4	1.43548	1.44307	39.5

239. B = **$C_2H_4O_2$**, Acetic acid (133, 136)

t	n_D^t	$d_4^{t'}$	t'
0.000% B			
6.8	1.63816	1.27348	13.4
20.9	1.62694	1.25983	22.6
34.5	1.61588	1.24283	33.9
12.076% B			
11.9	1.58723	1.22831	13.5
23.1	1.57854	1.21786	20.6
44.3	1.56172	1.20261	30.8
61.284% B			
13.9	1.44695	1.10562	14.7
21.1	1.44281	1.09475	22.7
35.0	1.43461	1.08355	30.7
80.298% B			
11.5	1.40855	1.07807	13.0
23.0	1.40300	1.06871	20.7
41.2	1.39424	1.05643	30.1

CS_2.—(*Continued*)

239.—(*Continued*)

t	n_D^t	$d_4^{t'}$	t'
100.000% B			
21.2	1.37146	1.05819	12.5
31.7	1.36738	1.04546	23.9
49.7	1.36014	1.03897	30.4

240. B = $C_2H_5NO_3$, Ethyl nitrate (105)

% B	n_F^{15}	$d_4^{t'}$	t'
0.00	1.65513	1.26839	16.8
46.73	1.51012	1.17388	15.0

241. B = C_2H_6O, Ethyl alcohol; t = 20°C (134)

% B	n_F^t	d_4^t
0.000	1.65268	1.26354
20.182	1.56279	1.12167
31.966	1.52081	1.05425
49.234	1.47039	0.97177
100.000	1.36676	0.79628

242. B = C_3H_6O, Acetone (70, 71); *cf.* (152)

% A	n_D^{52}
0.000	1.35645
13.245	1.37576
29.326	1.40364
40.329	1.42567
51.761	1.45253
51.799	1.45253
51.902	1.45271
71.137	1.50692
83.283	1.55043
86.892	1.56465
100.000	1.62357

243. B = $C_3H_8O_2$, Methylal

t = 25°C (70, 71)	
0.000	1.35018
12.921	1.37164
28.682	1.40178
38.408	1.42294
45.630	1.44005
53.139	1.45922
60.034	1.47810
62.38	1.48497
65.262	1.49357
75.141	1.52508
86.449	1.56665
100.000	1.62357
t = 25.4°C (152); *cf.* (82)	
0.00	1.35064
10.14	1.36739
20.24	1.38556
30.45	1.40622
40.45	1.42831
50.28	1.45247
60.06	1.47892
69.75	1.50863
80.00	1.54264
89.73	1.57937
94.25	1.59829
100.00	1.62341

244. B = $C_4H_8O_2$, Isobutyric acid (133, 136)

t	n_D^t	$d_4^{t'}$	t'
0.000% B			
6.8	1.63816	1.27348	13.4
20.9	1.62694	1.25983	22.6
34.5	1.61588	1.24283	33.9
20.336% B			
11.75	1.56445	1.18353	13.3
19.5	1.55908	1.17067	22.7
34.5	1.54810	1.15993	30.1
45.276% B			
11.2	1.49687	1.09615	12.4
18.2	1.49253	1.08550	21.1
30.8	1.48470	1.07236	31.0
68.028% B			
13.2	1.44813	1.03144	13.1
18.4	1.44515	1.02316	20.4
38.0	1.43480	1.01398	28.2
100.000% B			
9.1	1.39689	0.96211	11.4
25.9	1.38973	0.93921	34.2
39.4	1.38394	0.91978	53.2
68.4	1.37145	0.89795	74.4

245. B = $C_4H_{10}O$, Isobutyl alcohol (133, 136)

t	n_D^t	$d_4^{t'}$	t'
15.803% B			
9.6	1.57631	1.16304	11.3
28.9	1.56198	1.15392	18.7
39.7	1.55357	1.13648	31.7
30.008% B			
8.3	1.53380	1.07702	13.9
25.2	1.52266	1.06903	21.1
33.6	1.51664	1.05245	34.2
50.220% B			
11.8	1.48276	0.97919	15.5
22.1	1.47679	0.96248	30.7
70.388% B			
9.5	1.44470	0.90118	13.8
22.4	1.43825	0.88336	32.4
100.000% B			
23.7	1.39372	0.80680	16.2
34.9	1.38912	0.79423	31.8

246. B = $C_4H_{10}O$, Ethyl ether (135)

t	n_{5876}^t	$d_4^{t'}$	t'
0.000% B			
19.1	1.62783	1.26037	21.0
28.3	1.62070	1.24069	34.2
20.3505% B			
24.0	1.53524	1.08508	24.2
30.2	1.53084	1.07455	31.5
29.6571% B			
25.4	1.50187	1.02038	25.0
30.3	1.49773	1.01067	31.8
41.5400% B			
24.4	1.46729	0.95077	23.7
30.3	1.46336	0.94204	30.0
59.9864% B			
25.3	1.42070	0.85919	23.0
30.6	1.41679	0.84799	31.6
79.7398% B			
25.7	1.38123	0.77530	25.5
100.000% B			
24.8	1.34974	0.70920	23.7
29.7	1.34665	0.69894	32.3

247. B = $C_5H_{10}O_2$, Isovaleric acid (133, 136)

t	n_D^t	$d_4^{t'}$	t'
28.295% B			
9.5	1.54626	1.14718	12.1
20.3	1.53891	1.13613	20.7
32.0	1.53095	1.12267	30.7
45.900% B			
8.0	1.50346	1.08096	14.2
19.8	1.49639	1.07130	22.3
26.6	1.49213	1.06044	31.2
62.573% B			
11.2	1.46666	1.03281	10.2
20.5	1.46158	1.02326	19.7
37.7	1.45234	1.01100	30.7
100.000% B			
8.1	1.40736		
28.3	1.39888	0.93319	17.6
41.9	1.39322	0.91204	40.2
57.0	1.38694	0.89222	60.8

$CHBr_3$

Bromoform

248. B = $CHCl_3$, Chloroform (51)

% B	n_D^{25}
0.00	1.58794
7.88	1.57086
20.87	1.54356
23.47	1.53988
24.34	1.53690
38.92	1.51184
54.12	1.49001
78.11	1.46360
100.00	1.44260

$CHCl_3$

Chloroform; *cf.* (42, 75)

249. B = $C_2H_4O_2$, Acetic acid (137)

t	n_D^t	$d_4^{t'}$	t'
27.584% A			
12.9	1.38763	1.14511	14.5
22.0	1.38411	1.13496	22.3
39.4	1.37635	1.12221	32.0
50.994% A			
12.1	1.40315	1.23599	14.5
22.8	1.39811	1.22515	21.9
39.2	1.39015	1.21275	30.0
68.619% A			
13.0	1.41733	1.31752	14.7
24.0	1.41157	1.30404	23.1
43.9	1.40068	1.29206	30.3
80.763% A			
10.0	1.43019	1.38688	11.7
21.6	1.42373	1.37281	20.0
41.8	1.41225	1.35469	30.4

250. B = C_2H_6O, Ethyl alcohol (137)

t	n_D^t	$d_4^{t'}$	t'
0.000% A			
10.8	1.36501	0.79693	11.3
18.7	1.36185	0.78884	21.0
47.5	1.34984	0.78152	29.3
19.522% A			
8.7	1.37626	0.87860	11.7
24.9	1.36944	0.86882	22.0
30.2	1.36711	0.86055	30.6
27.661% A			
10.0	1.38036	0.91587	11.3
25.0	1.37367	0.90777	19.7
33.0	1.37028	0.89725	29.8
34.824% A			
6.2	1.38714	0.95644	10.7
17.3	1.38211	0.94825	18.7
36.6	1.37331	0.93548	30.3
49.079% A			
11.0	1.39537	1.04136	10.2
22.4	1.39002	1.02775	21.9
35.8	1.38351	1.01505	32.0
60.901% A			
10.5	1.40539	1.11711	14.5
24.2	1.39849	1.10569	23.1
31.3	1.39486	1.09548	30.5
78.429% A			
7.3	1.42431	1.26612	10.9
17.4	1.41877	1.25308	19.4
36.5	1.40795	1.23663	29.7
87.414% A			
11.8	1.43251	1.35474	10.9
24.0	1.42556	1.33693	21.7
37.5	1.41754	1.32113	30.7
100.000% A			
10.1	1.45206	1.50584	11.2
25.2	1.44290	1.49090	19.3
43.5	1.43176	1.46987	30.6

251. B = C_3H_6O, Acetone (137); *cf.* (70, 152)

t	n_D^t	$d_4^{t'}$	t'
0.000% A			
9.6	1.36436	0.7991	13.4
20.4	1.35874	0.7928	19.2
37.4	1.34962	0.7850	26.0
22.396% A			
10.6	1.37533	0.89393	11.7
24.4	1.36803	0.88351	20.5
36.0	1.36171	0.87181	30.0
41.577% A			
11.7	1.38724	0.99346	11.8
28.0	1.37847	0.97933	23.0
36.2	1.37399	0.96852	30.1
56.889% A			
10.2	1.40037	1.09070	12.0
21.0	1.39460	1.07611	22.4
36.5	1.38609	1.06194	31.6
84.064% A			
12.4	1.42835	1.32149	11.8
20.0	1.42388	1.30576	21.5
36.3	1.41456	1.28932	31.1
93.901% A			
12.2	1.44168	1.42861	12.2
19.0	1.43788	1.41283	21.2
31.2	1.43034	1.39038	33.4

251.—(*Continued*)
(70); *cf.* (71, 152)

% A	n_D^{25}
0.00	1.35621
16.664	1.36454
33.039	1.37417
45.832	1.38332
56.298	1.39196
64.507	1.39943
72.276	1.40757
79.884	1.41618
88.409	1.42692
94.292	1.43487
100.000	1.44309

See also 238, 248.

CH_2I_2

Methylene iodide

252. B = **$C_6H_{10}O_4$**, Diethyl oxalate (105)

% A	n_F^{15}	d_4^{15}
0.00	1.41781	1.08547
75.50	1.57322	2.18438
100.00	1.77266	3.3398

CH_2O

Formaldehyde; *see* 20

CH_2O_2

Formic acid

253. B = **$C_{10}H_{16}O$**, Camphor (53)

% B	n_D^{20}	d_4^{20}
0.00	1.3709	1.2201
8.44	1.3794	1.1881
17.27	1.3891	1.1579
26.56	1.3971	1.1313
36.31	1.4063	1.1026
46.54	1.4175	1.0746

If % B < 50, a = 1.3709, b = 0.9775, ϵ = 1 or 2.

CH_4N_2S

Ammonium thiocyanate; *see* 21

CH_4O

Methyl alcohol

254. B = **CdI_2**, Cadmium iodide; t = 20.5°C (48)

% B	n_D^t	d_4^t
0.000	1.32875	0.7942
0.012	1.32887	0.7942
0.115	1.32887	0.7943
0.460	1.32932	0.7969
1.150	1.33016	0.8021
2.301	1.33159	0.8099
4.602	1.33452	0.8269
11.555	1.34300	0.8766

If % B < 11.6, a = 1.32875, b = 1.235, c = 0, ϵ = 1.

255. B = **$C_2H_3NaO_2$**, Sodium acetate; t = 25°C (84)

5	1.33279	0.8134

256. B = **$C_2H_4O_2$**, Acetic acid; t = 25°C (84)

% B	n_D^t	d_4^t
0	1.32663	0.7894
5	1.32978	0.8021

257. B = **C_2H_6O**, Ethyl alcohol; t = 15°C (36)

% B	n_D^t
0.00	1.33057
10.63	1.33390
21.22	1.33740
32.03	1.34115
41.21	1.34422
49.84	1.34697
61.08	1.35070
74.895	1.35517
81.31	1.35718
90.10	1.36010
100.00	1.36330

$100n = n_A(\% A) + n_B(\% B)$; ϵ = 1 or 2.

258. B = **$C_3H_5NaO_2$**, Sodium propionate; t = 25°C (84)

% B	n_D^t	d_4^t
5	1.33415	0.8146

259. B = **$C_3H_6O_2$**, Propionic acid; t = 25°C (84)

5	1.33176	0.8036

260. B = **C_3H_8O**, *n*-Propyl alcohol; t = 15°C (36)

% B	n_D^t
0.00	1.33053
4.37	1.33312
9.88	1.33603
34.63	1.35002
40.90	1.35394
59.62	1.36423
68.12	1.36900
78.94	1.37518
88.035	1.38036
100.00	1.38726

$100n = n_A(\% A) + n_B(\% B)$; ϵ = 1 or 2.

261. B = **$C_4H_7NaO_2$**, Sodium butyrate; t = 25°C (84)

% B	n_D^t	d_4^t
5	1.33540	0.8156

262. B = **$C_4H_8O_2$**, Butyric acid; t = 25°C (84)

5	1.33350	0.8050

263. B = **$C_4H_{10}O$**, Isobutyl alcohol; t = 15°C (36)

% B	n_D^t
0.00	1.33053
5.34	1.33484
14.19	1.34055
22.545	1.34620
39.47	1.35710
49.415	1.36372
89.84	1.39102
100.00	1.39750

n is not quite linear in % B.

264. B = **C_5H_5N**, Pyridine; t = 17.5°C (147)

g B/l soln.	n_D^t
0.00	1.32979
7.98	1.33130
15.96	1.33285
59.80	1.34124
119.59	1.35257

If g B/l soln. < 120, $n_D^{17.5}$ = {1.32979 + 0.00019(g B/l soln.)} ± 0.0001.

265. B = **$C_5H_9NaO_2$**, Sodium valerate; t = 25°C (84)

% B	n_D^t	d_4^t
5	1.33508	0.8160

266. B = **$C_5H_{10}O_2$**, Valeric acid; t = 25°C (84)

5	1.33500	0.8066

267. B = **$C_6H_3KN_2O_5$**, 2, 3-Dinitrophenolate; t = 25°C (84)

5	1.33251	0.8106

268. B = **$C_6H_3KN_2O_5$**, 2, 4-Dinitrophenolate; t = 25°C (84)

5	1.33375	0.8112

269. B = **$C_6H_3KN_2O_5$**, 2, 6-Dinitrophenolate; t = 25°C (84)

5	1.33395	0.8115

270. B = **$C_6H_3KN_2O_5$**, 3, 4-Dinitrophenolate; t = 25°C (84)

5	1.33242	0.8105

271. B = **$C_6H_3KN_2O_5$**, 3, 6-Dinitrophenolate; t = 25°C (84)

5	1.33240	0.8104

272. B = **$C_6H_4KNO_3$**, *o*-Nitrophenolate; t = 25°C (84)

2.5	1.32654	0.7909

273. B = **$C_6H_4KNO_3$**, *m*-Nitrophenolate; t = 25°C (84)

2.5	1.32335	0.7900

274. B = **$C_6H_4KNO_3$**, *p*-Nitrophenolate; t = 25°C (84)

2.5	1.32910	0.7940

275. B = **$C_6H_4N_2O_5$**, 2, 3-Dinitrophenol; t = 25°C (84)

5	1.33234	0.8050

276. B = **$C_6H_4N_2O_5$**, 2, 4-Dinitrophenol; t = 25°C (84)

5	1.33270	0.8056

277. B = **$C_6H_4N_2O_5$**, 2, 6-Dinitrophenol; t = 25°C (84)

5	1.33290	0.8058

278. B = **$C_6H_4N_2O_5$**, 3, 4-Dinitrophenol; t = 25°C (84)

5	1.33217	0.8048

279. B = **$C_6H_4N_2O_5$**, 3, 6-Dinitrophenol; t = 25°C (84)

5	1.33231	0.8049

280. B = **$C_6H_5KO_3S$**, Benzenesulfonate; t = 25°C (84)

5	1.32689	0.8015

281. B = **$C_6H_5NO_3$**, *o*-Nitrophenol; t = 25°C (84)

% B	n_D^t	d_4^t
5	1.33020	0.7951

282. B = **$C_6H_5NO_3$**, *m*-Nitrophenol; t = 25°C (84)

5	1.32850	0.7957

283. B = **$C_6H_5NO_3$**, *p*-Nitrophenol; t = 25°C (84)

5	1.32880	0.8006

284. B = **C_6H_6**, Benzene; t = 17.5°C (147)

g B/l soln.	n_D^t
0.00	1.32979
4.07	1.33057
8.13	1.33133
15.01	1.33266
30.03	1.33549
49.58	1.33924
105.72	1.34988
156.60	1.35961

If g B/l soln. < 40, $n_D^{17.5}$ = {1.32979 + 0.000285(gB/l soln.)} ±0.0001.

285. B = **$C_6H_6O_3S$**, Benzenesulfonic acid; t = 25°C (84)

% B	n_D^t	d_4^t
5	1.32989	0.8002

286. B = **$C_7H_4NNaO_4$**, *o*-Nitrobenzoate; t = 25°C (84)

5	1.33510	0.8189

287. B = **$C_7H_4NNaO_4$**, *m*-Nitrobenzoate; t = 25°C (84)

5	1.33479	0.8188

288. B = **$C_7H_4NNaO_4$**, *p*-Nitrobenzoate; t = 25°C (84)

5	1.33528	0.8189

289. B = **$C_7H_5KN_2O_4$**, *aci-o*-Nitrophenylnitromethane; t = 25°C (84)

2.5	1.32842	0.7990

290. B = **$C_7H_5NO_4$**, *o*-Nitrobenzoic acid; t = 25°C (84)

5	1.33290	0.8120

291. B = **$C_7H_5NO_4$**, *m*-Nitrobenzoic acid; t = 25°C (84)

5	1.33290	0.8118

292. B = **$C_7H_5NO_4$**, *p*-Nitrobenzoic acid; t = 25°C (84)

5	1.33291	0.8120

293. B = **$C_7H_5N_2NaO_4$**, *aci-p*-Nitrophenylnitromethane; t = 25°C (84)

2.5	1.32870	0.7987

294. B = **$C_7H_5NaO_2$**, Benzoate; t = 25°C (84)

5	1.33466	0.8160

295. B = **$C_7H_6N_2O_4$**, *aci-o*-Nitrophenylnitromethane; t = 25°C (84)

2.5	1.32811	0.7962

CH_4O.—(*Continued*)

296. B = $C_7H_6N_2O_4$, *aci-p*-Nitrophenylnitromethane; t = 25°C (84)

% B	n_D^t	d_4^t
2.5	1.32802	0.7960

297. B = $C_7H_6O_2$, Benzoic acid; t = 25°C (84)

5	1.33369	0.8100

298. B = C_9H_7N, Quinoline; t = 17.5°C (147)

g B/l soln.	n_D^t
0.00	1.32979
19.82	1.33549
39.64	1.34111

If g B/l soln. < 40, $n = \{1.32979 + 0.000285(\text{g B/l soln.})\} \pm 0.0001$.

299. B = $C_{10}H_8$, Naphthalene; t = 17.5°C (147)

% B	n_D^t
0.00	1.32979
1.07	1.33208
1.99	1.33435
3.91	1.33888

If % B < 4, $n = \{1.32979 + 0.00232(\% \text{B})\} \pm 0.0001$.

300. B = $C_{10}H_{16}O$, Camphor; t = 20°C (53)

% B	n_D^t	d_4^t
0.00	1.3290	0.7912
12.34	1.3435	0.8102
24.14	1.3576	0.8286
35.46	1.3723	0.8472
46.26	1.3876	0.8649
56.66	1.4026	0.8827

If % B < 50, a = 1.3290, b = 1.112, c = 3.24, ϵ = 2 or 3.

301. B = $C_{12}H_{10}$, Diphenyl; t = 17.5°C (147)

% B	n_D^t
0.00	1.32979
0.355	1.33062
1.40	1.33296
1.71	1.33370
2.76	1.33603
3.24	1.33743
6.50	1.34485

If % B < 6.5, a = 1.32979, b = 2.32, c = 0, ϵ = 1.

302. B = $C_{19}H_{16}$, Triphenylmethane; t = 17.5°C (147)

0.00	1.32979
0.543	1.33097
0.717	1.33135
1.42	1.33293

If % B < 1.5, a = 1.32979, b = 2.21, c = 0, ϵ = 1.

See also 22, 552.

$C_2HCl_3O_2$

Trichloracetic acid; *see* 23

$C_2H_2O_4$

Oxalic acid; *see* 24, 553

$C_2H_4Br_2$

Ethylene bromide; *cf.* (128)

303. B = $C_3H_6Br_2$, Propylene bromide; t = 25.4°C (152)

% B	n_D^t
0.00	1.53601
6.06	1.53466
19.74	1.53190
26.97	1.53048
32.10	1.52953
40.27	1.52797
51.64	1.52588
60.11	1.52430
69.72	1.52263
80.27	1.52081
90.64	1.51898
100.00	1.51745

304. B = C_7H_8, Toluene; t = 25°C (129)

0.00	1.5363
10.00	1.5250
20.00	1.5170
30.00	1.5110
40.00	1.5065
50.00	1.5028
60.00	1.5000
70.00	1.4977
80.00	1.4960
90.00	1.4943
100.00	1.4929

305. B = $C_{10}H_8$, Naphthalene; t = 17.4°C (76)

% B	n_D^t	d_4^t
0.000	1.53832	2.1639
9.629	1.55250	1.9540
14.407	1.55897	1.8655

See also 231, 586.

$C_2H_4Cl_2$

Ethylene chloride

306. B = $C_2H_4O_2$, Acetic acid (137)

t	n_D^t	$d_4^{t'}$	t'
26.593% A			
9.0	1.39018	1.10223	10.1
21.2	1.38488	1.09026	20.0
41.8	1.37589	1.07690	31.3
46.948% A			
9.7	1.40307	1.13834	11.4
20.2	1.39835	1.12615	20.9
37.2	1.39022	1.11395	30.3
69.568% A			
8.6	1.42113	1.18804	10.4
23.5	1.41370	1.17327	21.3
42.0	1.40431	1.16102	30.3
88.390% A			
9.0	1.43825	1.23438	10.7
28.5	1.42811	1.22088	20.2
52.3	1.41534	1.20640	30.2

307. B = C_3H_6O, Acetone (137)

t	n_D^t	$d_4^{t'}$	t'
26.844% A			
9.8	1.38058	0.88827	11.9
23.8	1.37294	0.87478	23.3
51.575% A			
7.8	1.39938	0.98873	11.2
20.3	1.39283	0.97591	21.4
72.414% A			
9.8	1.41774	1.09289	10.3
25.9	1.40894	1.07983	20.1
86.874% A			
12.1	1.43198	1.17482	12.5
23.3	1.42592	1.16078	22.6
100.000% A			
9.7	1.45031	1.25759	17.2
25.4	1.44178	1.24792	23.8
43.0	1.43210	1.23841	30.1

308. B = C_6H_6, Benzene (152)

% A	$n_D^{25.2}$
0.00	1.49779
10.16	1.49294
23.25	1.48641
30.30	1.48273
41.35	1.47696
49.40	1.47270
60.07	1.46687
60.44	1.46643
71.04	1.46041
78.81	1.45572
90.80	1.44842
100.00	1.44225

C_2H_4O

Acetaldehyde

309. B = C_2H_6O, Ethyl alcohol (78); *cf.* (134)

% A	n_D^{18}
0.00	1.3601
10.01	1.3660
20.99	1.3720
21.61	1.3727
30.58	1.3764
36.36	1.3784
42.01	1.3790
52.04	1.3775
61.56	1.3718
74.10	1.3614
81.10	1.3538
100.00	1.3392

$C_2H_4O_2$

Acetic acid; *cf.* (20, 155)

310. B = C_4H_9Br, Butyl bromide (137)

t	n_D^t	$d_4^{t'}$	t'
21.961% B			
14.1	1.38150	1.08095	14.4
24.4	1.37717	1.07000	23.5
44.4	1.36843	1.06157	30.3
43.647% B			
13.5	1.39173	1.11132	14.4
24.0	1.38693	1.10189	21.7
36.1	1.38118	1.08960	31.0

310.—(*Continued*)

t	n_D^t	$d_4^{t'}$	t'
68.091% B			
13.2	1.40554	1.15152	14.4
40.7	1.39116	1.12783	31.0
100.000% B			
10.4	1.43228	1.22678	10.8
26.0	1.42332	1.21142	20.5
58.8	1.40357	1.19534	30.2

311. B = C_5H_5N, Pyridine (152)

% A	$n_D^{25.2}$
0.00	1.50695
4.62	1.50170
10.21	1.49523
20.30	1.48399
30.40	1.47284
40.40	1.46235
50.05	1.45277
60.07	1.44335
70.24	1.43312
79.80	1.42051
90.35	1.39891
100.00	1.37015

312. B = C_6H_6, Benzene (70, 71); *cf.* (152)

% A	n_D^{25}
0.000	1.49794
11.634	1.48218
23.614	1.46628
34.008	1.45265
44.857	1.43861
54.459	1.42618
63.968	1.41418
73.819	1.40172
82.321	1.39119
91.338	1.38023
100.000	1.36976

313. B = C_6H_7N, Aniline (51)

% B	n_D^{25}
0.00	1.37070
11.87	1.40811
33.33	1.46261
38.65	1.47446
57.10	1.51066
65.54	1.52412
79.16	1.54916
93.31	1.53718
100.00	1.58118

314. B = C_7H_8, Toluene (152)

% A	$n_D^{25.2}$
0.00	1.49366
4.69	1.48785
9.20	1.48224
19.75	1.46910
29.75	1.45667
40.27	1.44360
49.90	1.43166
60.11	1.41921
69.94	1.40691
79.88	1.39469
89.84	1.38242
100.00	1.37003

315. B = $C_{10}H_{16}O$, Camphor (53)

% B	n_D^{20}	d_4^{20}
0.00	1.3713	1.0495
9.64	1.3811	1.0397
19.40	1.3913	1.0308
29.45	1.4010	1.0211
39.56	1.4115	1.0115
49.89	1.4221	1.0022

If % B < 50, a = 1.3713, b = 1.018, ϵ = 1 or 2.

See also 25, 232, 239, 249, 256, 306, 554.

$C_2H_4O_3$

Glycolic acid; *see* 26, 555

C_2H_5Br

Ethyl bromide

316. B = C_3H_6O, Acetone (137)

t	n_D^t	$d_4^{t'}$	t'
	0.000 % A		
9.6	1.36436	0.79279	19.2
20.4	1.35874	0.78499	26.0
	33.110 % A		
16.9	1.37269	0.93226	18.3
28.7	1.36610	0.91795	28.7
	50.812 % A		
16.3	1.38202	1.02784	19.2
28.3	1.37507	1.01465	28.0
	67.809 % A		
16.8	1.39290	1.14969	14.9
24.7	1.38845	1.12158	29.8
	100.000 % A		
16.0	1.42577	1.45543	20.9
32.1	1.41556	1.44561	25.6

C_2H_5BrO

Ethylenebromohydrin; *see* 27

C_2H_5ClO

Ethylenechlorohydrin (54)

C_2H_5I

Ethyl iodide

317. B = $C_4H_8O_2$, Ethyl acetate (70, 71); *cf.* (152)

% A	n_D^{25}
0.000	1.37005
19.082	1.38150
35.007	1.39393
49.517	1.40822
59.741	1.42090
68.529	1.43402
74.566	1.44447
82.792	1.46121
89.093	1.47646
94.970	1.49318
100.000	1.50992

See also 233.

$C_2H_5NO_3$

Ethyl nitrate

318. B = C_7H_{16}, Heptane (105)

% B	n_C^{15}	$d_4^{t'}$	t'
0.00	1.38509*	1.11315	16.2
38.16	1.38442	0.89599	15.0
100.00	1.38855		

* At 16.2°C.

319. B = $C_{10}H_7Br$, α-Bromonaphthalene (105)

59.99	1.51739	1.30677	15
100.00	1.65186	1.49340	15

See also 240.

C_2H_6O

Ethyl alcohol; *cf.* (50, 63, 68, 75, 131)

320. B = CdI_2, Cadmium iodide (48)

% B	$n_D^{20.5}$	$d_4^{20.5}$
0.000	1.36104	0.7891
0.116	1.36117	0.7900
0.232	1.36136	0.7911
0.464	1.36148	0.7924
1.160	1.36219	0.7973
2.321	1.36355	0.8052
4.641	1.36559	0.8210
5.802	1.36695	0.8292
11.613	1.37289	0.8688
23.206	1.38517	0.9484
46.412	1.40964	1.1068

321. B = C_3H_8O, *n*-Propyl alcohol; t = 25°C (99, 100)

% A	n_D^t
0.00	1.3833
12.54	1.3803
25.00	1.3772
37.49	1.3742
50.02	1.3712
62.40	1.3681
74.93	1.3649
87.50	1.3619
100.00	1.3590

$100n = n_A(\%\ A) + n_B(\%\ B)$, ϵ = 1 or 2.

For A, d_4^{25} = 0.78516 (=99.97% C_2H_6O).

For B, d_4^{25} = 0.8004 (=99.35% C_3H_8O).

322. B = C_3H_8O, Isopropyl alcohol; t = 25°C (99, 100)

0.00	1.3750
17.23	1.3721
33.60	1.3697
49.87	1.3673
66.89	1.3646
83.61	1.3622
100.00	1.3595

$100n = n_A(\%\ A) + n_B(\%\ B)$, ϵ = 1 or 2.

For A, d_4^{25} = 0.78516 (=99.97% C_2H_6O).

For B, d_4^{25} = 0.78086 (=99.99% C_3H_8O).

323. B = $C_4H_{10}O$, Isobutyl alcohol; t = 15°C (36)

% A	n_D^t
0.00	1.39750
31.46	1.38644
40.91	1.38312
50.51	1.37995
70.94	1.37295
87.66	1.36734
93.695	1.36542
100.00	1.36330

n is not quite linear in % B.

324. B = C_6H_6, Benzene; t = 18°C (80)

0	1.5024
10	1.4869
20	1.4716
30	1.4568
40	1.4425
50	1.4283
60	1.4146
70	1.4011
80	1.3878
90	1.3749
100	1.3622

325. B = C_6H_7N, Aniline (95)

% B	n_D^{25}
0.00	1.3596
9.81	1.3782
20.49	1.3993
29.71	1.4183
36.37	1.4317
50.88	1.4630
59.61	1.4830
71.46	1.5110
80.99	1.5343
88.73	1.5531
100.00	1.5842

326. B = $C_6H_8O_2$, Cyclohexan-1, 4-dione (26)

% B	n_C^t	d_4^t	t
0.00	1.36097	0.79252	16.8
7.55	1.36792	0.81303	17.5
8.08	1.36853	0.81466	17.4

327. B = C_7H_8, Toluene; t = 18°C (80)

% A	n_D^t
0	1.4970
10	1.4823
20	1.4680
30	1.4539
40	1.4401
50	1.4265
60	1.4131
70	1.4000
80	1.3873
90	1.3747
100	1.3622

328. B = $C_9H_6Br_2O_2$, Dibromocinnamic acid; t = 25°C (151)

% B	n_D^{25}	d_4^{25}
0.000	1.35954	0.7851
5.205	1.36603	0.8107

329. B = $C_9H_7BrO_2$, α-Bromocinnamic acid; t = 25°C (151)

% B	n_D^{25}	d_4^{25}
0.000	1.35967	0.7851
4.677	1.36691	0.8053
5.041	1.36742	0.8069
5.192	1.36780	0.8076

330. B = $C_9H_7BrO_2$, β-Bromocinnamic acid; t = 25°C (151)

0.000	1.35954	0.7851
4.512	1.36623	0.8045
4.877	1.36681	0.8062

331. B = $C_9H_7BrO_2$, α-Bromoallocinnamic acid; t = 25°C (151)

0.000	1.35967	0.7851
4.824	1.36681	0.8056
5.248	1.36747	0.8075
5.320	1.36757	0.8077

332. B = $C_9H_7BrO_2$, β-Bromoallocinnamic acid; t = 25°C (151)

0.000	1.35954	0.7851
5.044	1.36649	0.8061

333. B = $C_9H_7ClO_2$, α-Chlorocinnamic acid; t = 25°C (151)

0.000	1.35967	0.7851
4.984	1.36851	0.8026
5.136	1.36879	0.8031
5.190	1.36893	0.8034
5.469	1.36930	0.8042

334. B = $C_9H_7ClO_2$, α-Chloroallocinnamic acid; t = 25°C (151)

0.000	1.35954	0.7851
5.008	1.36758	0.8021
5.051	1.36767	0.8024
5.260	1.36776	0.8024

335. B = $C_{10}H_{15}BrO$, Bromocamphor; t = 25°C (104)

% B	n_D^t	d_4^t
0.000	1.3602	0.7878
0.5078	1.3605	0.7892
4.978	1.3647	0.8040
9.765	1.3693	0.8213
14.320	1.3739	0.8379
18.730	1.3788	0.8549

If % B < 20, a = 1.3600, b = 0.92, c = 4; ϵ = 1 or 2.

336. B = $C_{10}H_{16}O$, Camphor; t = 20°C (53)

0.00	1.3618	0.7939
12.32	1.3735	0.8129
24.10	1.3846	0.8304
35.57	1.3961	0.8478
46.25	1.4076	0.8649
56.79	1.4191	0.8822

If % B < 50, a = 1.3618, b = 0.902, c = 1.84; ϵ = 1 or 2.

C_2H_6O.—(*Continued*)

336.—(*Continued*)

% B	n_D^t	d_4^t
t = 25°C (104)		
0.000	1.3600	0.7874
0.7643	1.3606	0.7886
3.050	1.3629	0.7918
7.538	1.3673	0.7987
14.820	1.3736	0.8094
24.280	1.3832	0.8239
37.830	1.3971	0.8460
50.720	1.4108	0.8671

If % B < 50, a = 1.3600, b = 0.9075, c = 1.85; ε = 1.

337. B = $C_{10}H_{18}O$, Borneol; t = 25°C (103)

0.000	1.3602	0.7878
1.0162	1.3613	0.7889
2.736	1.3635	0.7921
3.586	1.3636	0.7934
5.290	1.3659	0.7944
7.541	1.3682	0.7998
9.967	1.3711	0.8040
24.330	1.3872	0.8278
35.070	1.3993	0.8466

If % B < 35, a = 1.3602, b = 1.115, c = 0; ε = 2.

338. B = $C_{12}H_{12}O_2$, 2-Benzoylcyclopentanone (9)

% B	n_D^t	d_4^t	t
0.000	1.36163	0.78534	25.0
4.520	1.37018	0.79784	25.0
6.454	1.37377	0.80310	25.2

339. B = $C_{13}H_{14}O_2$, 2-Benzoylcyclohexanone (9)

0.000	1.36163	0.78534	25.0
2.567	1.36583	0.79246	24.8
2.835	1.36617	0.79314	24.8

340. B = $C_{16}H_{31}KO_2$, Palmitate (84)

% B	n_D^{50}	d_0^{50}
2.5	1.35366	0.7552
5.0	1.35905	0.7560

341. B = $C_{16}H_{31}NaO_2$, Palmitate (84)

2.5	1.35363	0.7547

342. B = $C_{16}H_{32}O_2$, Palmitic acid (84)

0	1.34093	0.7490
5	1.36450	0.8100

343. B = $C_{18}H_{22}N_2$, Dibenzylpiperazine (25)

% B	n_C^{18}	d_4^{18}
0.00	1.36138*	0.79982
6.43	1.37235	0.81305

* t = 18.6°C.

344. B = $C_{18}H_{33}NaO_2$, Oleate (84)

% B	n_D^{50}	d_0^{50}
1.25	1.35490	0.7500
2.5	1.35862	0.7524

345. B = $C_{18}H_{34}O_2$, Oleic acid (84)

% B	n_D^{50}	d_0^{50}
0	1.34093	0.7490
5	1.36540	0.8114

346. B = $C_{18}H_{36}O_2$, Stearic acid (84)

0	1.34093	0.7490
5	1.36640	0.8133

347. B = $C_{19}H_{22}N_2O$, Cinchotoxine (103)

g B/l soln.	n_D^{25}	d_4^{25}
0.00	1.3602	0.7878
1.232	1.3607	0.7887
6.240	1.3617	0.7910
9.528	1.3630	0.7920
28.900	1.3667	0.7984
44.612	1.3695	0.8032
85.548	1.3796	0.8169
93.000	1.3800	0.8186

348. B = $C_{26}H_{26}N_2O_2$, Benzoylcinchotoxine (103)

0.000	1.3602	0.7878
9.704	1.3621	0.7911
21.028	1.3647	0.7954

See also 28, 241, 250, 257, 309, 556, 557, 558.

$C_2H_6O_2$

Glycol; *see* 29

$C_2H_7NO_2$

Ammonium acetate; *see* 30

$C_2H_8N_2O_4$

Ammonium oxalate; *see* 31

$C_3H_6Br_2$

Propylene bromide; *see* 303

C_3H_6O

Acetone; *cf.* (39)

349. B = C_3H_8O, Isopropyl alcohol (98)

% B	n_C^{22}
0.00	1.35633
1.38	1.35655
1.95	1.35651
2.41	1.35660
3.50	1.35701
5.07	1.35714
8.24	1.35754
9.71	1.35772
13.49	1.35834
15.10	1.35862
16.20	1.35871
29.30	1.36097
53.80	1.36537
67.30	1.36766
72.30	1.36940
89.90	1.37225
100.00	1.37470

a = 1.35633, b = 0.148, c = 0.35; ε = 1 or 2; $n_F^{22} = n_C^{22} + 0.00663$ for 0 < % B < 100.

350. B = C_6H_6, Benzene (39)

% A	n_D^{16}
0.0	1.5036
5.3	1.4962
9.8	1.4885
20.0	1.4723
31.0	1.4558
40.0	1.4426
49.5	1.4284
69.4	1.4011
84.7	1.3803
100.0	1.3609

351. B = $C_6H_6N_2O_2$, *o*-Nitroaniline; t = 20°C (58)

% B	n_D^t	d_4^t
4.4756	1.3687	0.8089
5.0076	1.3689	0.8093

352. B = $C_6H_6N_2O_2$, *p*-Nitroaniline; t = 20°C (58)

4.9334	1.3719	0.8111
5.6797	1.3736	0.8139

353. B = $C_{10}H_8$, Naphthalene (76)

% B	n_D^t	d_4^t	t
0.000	1.36126	0.7983	15.8
14.728	1.39380	0.8281	15.7
26.826	1.42257	0.8546	15.7
100.000	1.58218	0.9645	99.6

354. B = $C_{10}H_{15}BrO$, Bromocamphor (104)

% B	n_D^{25}	d_4^{25}
0.000	1.3571	0.7881
0.7693	1.3577	0.7901
7.381	1.3637	0.8117
22.930	1.3807	0.8719
34.720	1.3948	0.9219
48.580	1.4137	0.9884

If % B < 50, a = 1.3569, b = 0.917, c = 5.1; ε = 1 or 2.

355. B = $C_{10}H_{16}O$, Camphor (104)

0.000	1.3569	0.7874
0.7962	1.3576	0.7887
3.054	1.3597	0.7915
5.037	1.3613	0.7949
9.992	1.3665	0.8021
24.270	1.3807	0.8241
37.830	1.3945	0.8461
50.730	1.4091	0.8673
66.940	1.4283	0.8962

If % B < 50, a = 1.3569, b = 0.92, c = 2.1; ε = 1.

356. B = $C_{10}H_{18}O$, Borneol (103)

0.000	1.3571	0.7881
1.0302	1.3583	0.7860
2.9805	1.3613	0.7925
5.0730	1.3623	0.7960
9.9940	1.3675	0.8035
15.322	1.3739	0.8113
19.652	1.3791	0.8184
37.697	1.4005	0.8493

356.—(*Continued*)

If % B < 40, a = 1.3571, b = 1.0245; c = 3.7; ε = 2 or 3.

357. B = $C_{19}H_{22}N_2O$, Cinchotoxine (103)

g B/l soln.	n_D^{25}	d_4^{25}
0.00	1.3571	0.7881
5.160	1.3579	0.7898
21.136	1.3614	0.7951
41.592	1.3662	0.8015
60.348	1.3711	0.8100
88.712	1.3774	0.8152

358. B = $C_{26}H_{26}N_2O_2$, Benzoylcinchotoxine (103)

0.000	1.3571	0.7881
9.448	1.3581	0.7916
25.280	1.3623	0.7973
41.584	1.3651	0.8033
62.128	1.3726	0.8102

See also 32, 242, 251, 307, 316.

$C_3H_6O_2$

Propionic acid

359. B = $C_{10}H_{16}O$, Camphor (53)

% B	n_D^{20}	d_4^{20}
0.00	1.3847	0.9948
10.12	1.3940	0.9921
20.22	1.4026	0.9893
30.40	1.4123	0.9868
40.66	1.4213	0.9844
50.96	1.4309	0.9810

If % B < 50, a = 1.3847, b = 0.905, c = 0; ε = 1 or 2.

See also 33, 259, 559.

$C_3H_6O_2$

Methyl acetate; *v* (79)

$C_3H_6O_3$

Lactic acid; *see* 560

C_3H_8O

n-Propyl alcohol; *cf.* (128)

360. B = $C_5H_{11}I$, Amyl iodide; t = 25.1°C (153)

% B	n_D^t
0.00	1.38308
11.74	1.38976
22.41	1.39653
37.21	1.40740
45.35	1.41433
53.43	1.42071
60.15	1.42881
65.06	1.43453
73.79	1.44541
82.81	1.45792
86.78	1.46419
93.22	1.47559
97.12	1.48292
100.00	1.48863

Specific. rot. power of B was $[\alpha]_D = +1.54°\mathrm{cm}^2\mathrm{g}^{-1}$.

361. B = $C_{10}H_{16}O$, Camphor; t = 20°C (53)

% B	n_D^t	d_4^t
0.00	1.3855	0.8046
12.19	1.3940	0.8210
23.90	1.4030	0.8380
35.10	1.4124	0.8543
45.93	1.4212	0.8709
56.37	1.4293	0.8874

If % B < 40, a = 1.3855, b = 0.66, c = 2.75; ϵ = 1 or 2.

See also 34, 260, 321.

C_3H_8O

Isopropyl alcohol; *see* 35, 322, 349

$C_3H_8O_2$

Methylal; *see* 243

$C_3H_8O_3$

Glycerol; *see* 36

C_4H_5NS

Allyl isothiocyanate

362. B = $C_4H_{11}N$, Diethylamine; t = 25°C (52)

% B	n_D
0.00	1.52481
21.20	1.54033
32.60	1.54933
42.40	1.54928
53.97	1.51233
64.80	1.46856
100.00	1.38416

363. B = $C_5H_{11}N$ Piperidine; t = 25°C (52)

0.0	1.53066
15.8	1.54750
31.1	1.56700
46.2	1.57300
60.9	1.54995
71.8	1.50166
83.6	1.47933
100.0	1.45542

$C_4H_6O_4$

Succinic acid; *see* 37, 561

$C_4H_6O_5$

Malic acid; *see* 38, 562

$C_4H_6O_6$

Tartaric acid; *see* 39, 563, 564

$C_4H_8O_2$

Butyric acid; *see* 262

$C_4H_8O_2$

Isobutyric acid; *see* 244 and (44)

$C_4H_8O_2$

Ethyl acetate

364. B = $C_{10}H_{15}BrO$, Bromocamphor (104)

% B	n_D^{25}	d_4^{25}
0.000	1.3701	0.8947
0.4572	1.3710	0.8959
4.394	1.3749	0.9083
20.760	1.3920	0.9630
31.890	1.4049	1.0031
38.900	1.4136	1.0286

If % B < 40, a = 1.3704, b = 0.96, c = 3.75; ϵ = 1 or 2.

365. B = $C_{10}H_{16}O$, Camphor (104)

0.000	1.3704	0.8947
0.4656	1.3707	0.8951
1.119	1.3714	0.8953
2.671	1.3729	0.8967
4.468	1.3744	0.8979
8.882	1.3788	0.9004
22.000	1.3915	0.9091
34.850	1.4041	0.9176
51.690	1.4210	0.9283

If % B < 50, a = 1.3704, b = 0.97, c = 0; ϵ = 1 or 2.

366. B = $C_{10}H_{18}O$, Borneol (103)

0.000	1.3701	0.8947
0.8699	1.3711	0.8953
2.2461	1.3719	0.8965
4.433	1.3761	0.8976
8.951	1.3790	0.9004
17.663	1.3891	0.9063
26.301	1.3983	0.9127

If 0 < % B < 5, a = 1.3701, b = 0.65, c = 50; ϵ = 2.

If 5 < % B < 25, a = 1.3691, b = 1.12, c = 0; ϵ = 2.

See also 234, 317.

$C_4H_8S_2$

Diethylene disulfide

367. B = C_8H_{10}, Xylene (26)

% A	n_C^t	d_4^t	t
0.00	1.48790	0.85744	22.8
8.44	1.49265	0.87719	28.0
8.47	1.49270	0.87732	23.2

C_4H_9Br

Butyl bromide; *see* 310

$C_4H_9NO_6$

Ammonium bitartrate; *see* 40

$C_4H_{10}O$

n-Butyl alcohol

368. B = $C_8H_{14}O_6$, Diethyl tartrate (104)

% B	n_D^{25}	d_4^{25}
0.000	1.3979	0.8092
5.3231	1.3997	0.8206

368.—(*Continued*)

% B	n_D^{25}	d_4^{25}
23.1060	1.4067	0.8730
43.638	1.4148	0.9425
59.440	1.4228	1.0043
80.990	1.4339	1.1000

$C_4H_{10}O$

Isobutyl alcohol

369. B = $C_8H_{14}O_6$, Diethyl tartrate (104)

0.000	1.3944	0.7994
4.510	1.3960	0.8115
27.278	1.4044	0.8803
50.314	1.4157	0.9622
65.578	1.4240	1.0247
83.960	1.4353	1.1114

370. B = $C_{10}H_{16}O$, Camphor (104)

0.000	1.3944	0.7994
0.9796	1.3957	0.8007
4.9447	1.3979	0.8065
23.984	1.4108	0.8330
46.148	1.4262	0.8666
56.654	1.4342	0.8825

If % B < 50, a = 1.3944, b = 0.69, c = 0; ϵ = 1.

See also 245, 263, 323.

$C_4H_{10}O$

Trimethyl carbinol; *see* 41

$C_4H_{10}O$

Ethyl ether; *see* 246, 556 (42, 68, 75)

$C_4H_{10}O_4$

Erythritol; *see* 42

$C_4H_{11}N$

Diethylamine

371. B = C_7H_5NS, Phenyl isothiocyanate (52) t = 25°C

% A	n_D
0.00	1.64912
7.10	1.6373
16.20	1.6290
23.50	1.6245
35.10	1.6215
38.90	1.6060
42.60	1.5910
46.60	1.5710
58.80	1.5270
71.40	1.4867
80.50	1.4533
100.00	1.38725

See also 362.

$C_4H_{12}N_2O_4$

Ammonium succinate, *see* 43

$C_4H_{12}N_2O_6$

Ammonium tartrate; *see* 44

$C_5H_4O_2$

2-Furaldehyde; *see* 45

C_5H_5N

Pyridine

372. B = $C_{10}H_8$, Naphthalene (76)

% B	n_D^t	d_4^t	t
0.000	1.51137	0.9842	16.8
9.413	1.52209	0.9887	16.9
29.426	1.54462	0.9976	17.0
100.000	1.58218	0.9645	99.6

373. B = $C_{13}H_{10}N_4O_6$, α-Methylphenylpicramide (58)

% B	n_D^{20}	d_4^{20}
2.5590	1.5060	0.9919
2.5601	1.5063	0.9925

374. B = $C_{13}H_{10}N_4O_6$, β-Methylphenylpicramide

2.3446	1.5057	0.9911
2.5490	1.5059	0.9916

See also 46, 264, 311.

$C_5H_{10}O_2$

Valeric acid; *see* 266

$C_5H_{10}O_2$

Isovaleric acid; *see* 247

$C_5H_{10}O_2$

Propyl acetate

375. B = $C_5H_{10}O_2$, Ethyl propionate; t = 20°C (92)

% A	n_D
0.0000	1.53889
33.3914	1.53890
49.5407	1.53890
67.4112	1.53894
100.0000	1.53887

n is linear in % B for all λ's, to accuracy of 0.0001.

$C_5H_{10}O_2$

Ethyl propionate; *see* 375

$C_5H_{11}I$

Amyl iodide; *see* 360

$C_5H_{11}N$

Piperidine

376. B = C_6H_6, Benzene; t = 25°C (51)

% A	n_D
0.00	1.49856
15.56	1.49174
30.57	1.48402
40.77	1.47984
47.52	1.47289
58.12	1.47053
73.21	1.46459
82.79	1.45761
100.00	1.45542

See also 363.

$C_5H_{13}NO_2$

Ammonium valerate; *see* 47

$C_6H_4Br_2$

m-Dibromobenzene

377. B = C_9H_7N, Quinoline (76)

% A	n_D^t	d_4^t	t
0.000	1.63226	1.1018	9.6
52.574	1.62569	1.4342	9.4
0.000	1.62994	1.0979	14.8
29.635	1.62672	1.2634	14.8

$C_6H_4N_2O_5$

2, 3-Dinitrophenol; *see* 275

$C_6H_4N_2O_5$

2, 4-Dinitrophenol; *see* 276

$C_6H_4N_2O_5$

2, 6-Dinitrophenol; *see* 277

$C_6H_4N_2O_5$

3, 4-Dinitrophenol; *see* 278

$C_6H_4N_2O_5$

3, 6-Dinitrophenol; *see* 279

C_6H_5Cl

Chlorobenzene

378. B = $C_{10}H_{16}O$, Camphor (104)

% B	n_D^{25}	d_4^{25}
0.000	1.5246	1.1010
0.7255	1.5243	1.0992
5.509	1.5216	1.0920
18.643	1.5139	1.0719
30.350	1.5071	1.0538
59.250	1.4921	1.0138

No simple relation between *n* and % B.

$C_6H_5NO_2$

Nitrobenzene

379. B = C_6H_7N, Aniline; t = 20°C (16)

% B	n_D^t
0.00	1.55296
16.77	1.55902
29.27	1.56331
46.14	1.56913
62.49	1.57443
77.25	1.57919
100.00	1.58672

380. B = $C_{10}H_8$, Naphthalene (76)

% B	n_D^t	d_4^t	t
0.000	1.55595	1.2099	13.5
8.875	1.56205	1.1901	14.6
20.327	1.57040	1.1671	14.6

381. B = $C_{10}H_9N$, α-Naphthylamine (76)

0.000	1.55246	1.2021	20.8
8.943	1.56519	1.1939	20.8

$C_6H_5NO_3$

o-Nitrophenol; *see* 281

$C_6H_5NO_3$

m-Nitrophenol; *see* 282

$C_6H_5NO_3$

p-Nitrophenol; *see* 283

C_6H_6

Benzene; *cf.* (20, 39, 62, 75, 79, 130)

382. B = C_6H_7N, Aniline; t = 25°C (51)

% B	n_D^t
0.00	1.49856
23.95	1.51790
36.88	1.53020
50.44	1.54193
66.68	1.55535
75.85	1.56276
84.09	1.56963
100.00	1.58118

383. B = $C_7H_7NO_2$, *m*-Nitrotoluene (33)

% B	n_D^t	d_4^t
	t = 15°C	
0.0	1.50439	0.8841
30.5	1.51517	0.9536
50.4	1.52475	1.0130
72.4	1.53387	1.0692
87.8	1.54208	1.1197
100.0	1.54919	1.1603
	t = 30°C	
0.0	1.49534	0.8684
30.5	1.50687	0.9379
50.4	1.51698	0.9975
72.4	1.52665	1.0538
87.8	1.53520	1.1047
100.0	1.54263	1.1483

384. B = C_7H_9N, *m*-Toluidine (33)

	t = 15°C	
0.0	1.50439	0.8841
25.1	1.51966	0.9097
48.3	1.53405	0.9346
67.1	1.54713	0.9564
84.2	1.55898	0.9770
100.0	1.57068	0.9970
	t = 30°C	
0.0	1.49534	0.8684
25.1	1.51132	0.8947
48.3	1.52600	0.9204
67.1	1.53961	0.9428
84.2	1.55181	0.9640
100.0	1.56381	0.9848

385. B = C_7H_{16}, Heptane (105)

% B	n_C^{15}	$d_4^{8.5}$
0.00	1.38855	
56.26	1.44063	0.78278
100.00	1.50381	0.89137

386. B = $C_8H_{18}O$, 1-β-Octanol (34)

% B	n_D^{20}	d_{20}^{20}
0.00	1.5007	0.8788
2.386	1.4983	0.8773
2.989	1.4977	0.8767
5.458	1.4954	0.8745
5.666	1.4948	0.8737
8.259	1.4929	0.8722
9.942	1.4913	0.8704
13.801	1.4876	0.8679
18.933	1.4832	0.8647
23.122	1.4798	0.8618
23.742	1.4790	0.8608
29.846	1.4738	0.8567
36.021	1.4692	0.8532
42.262	1.4642	0.8493
49.430	1.4592	0.8453
54.021	1.4556	
57.807	1.4530	0.8406
61.631	1.4503	0.8385
65.575	1.4475	0.8368
68.481	1.4454	0.8358
77.747	1.4395	0.8308
84.473	1.4353	0.8276
92.456	1.4304	0.8241
98.098	1.4269	0.8218
100.000	1.4259	0.8215

Temperature controlled to ±0.1°.

387. B = $C_{10}H_{15}BrO$, Bromocamphor; t = 25°C (104)

% B	n_D^t	d_4^t
0.000	1.5004	0.8728
0.4665	1.4998	0.8743
4.512	1.4999	0.8871
21.210	1.5018	0.9431
32.500	1.5032	0.9848
46.120	1.5055	1.0409

If % B < 45, a = 1.4997, b = 0.078, c = 1; ϵ = 1 or 2.

388. B = $C_{10}H_{16}O$, Camphor

	t = 18.5°C (53)	
0.00	1.5017	0.8814
11.07	1.4980	0.8893
21.87	1.4945	0.8983
33.28	1.4912	0.9063
43.70	1.4882	0.9155
54.20	1.4853	0.9237
	t = 20°C (53)	
0.00	1.5014	0.8809
11:30	1.4961	0.8861
22.34	1.4931	0.8953
33.18	1.4903	0.9042
43.82	1.4874	0.9130
54.28	1.4842	0.9215
	n is not linear in % B.	
	t = 25°C (104)	
0.000	1.4997	0.8728
0.4472	1.4990	0.8728
0.928	1.4987	0.8736
2.722	1.4985	0.8748
4.550	1.4986	0.8766
9.097	1.4970	0.8802
22.470	1.4936	0.8913
35.480	1.4897	0.9019
52.373	1.4848	0.9164

If % B < 50, a = 1.4997, b = −0.2593, c = −0.53; ϵ = 1.

389. B = $C_{10}H_{18}O$, Borneol; = 25°C (103)

% B	n_D^t	d_4^t
0.000	1.5004	0.8728
0.9238	1.4995	0.8737
2.3214	1.4992	0.8747
4.586	1.4985	0.8765
11.348	1.4973	0.8813
16.940	1.4960	0.8864
22.455	1.4953	0.8909

If % B < 20, a = 1.5004, b = −0.4, c = 8; ϵ = 2.

390. B = $C_{10}H_{20}O_2$, 1-β-Octyl acetate (34)

% B	n_{5790}^{20}	d_{20}^{20}
0.000	1.5015	0.8802
4.350	1.4974	0.8787
9.738	1.4923	0.8777
15.842	1.4865	0.8762
23.142	1.4796	0.8742
29.168	1.4742	0.8732
36.850	1.4673	0.8718
43.254	1.4619	0.8708
55.207	1.4516	0.8687
70.726	1.4388	0.8661
81.118		0.8645
87.987	1.4245	0.8632
96.747	1.4176	0.8622
100.000	1.4153	0.8617

Same sample of C_6H_6 as for $C_8H_{18}O$, but it has probably absorbed traces of H_2O. Temperature controlled to 0.1°C.

391. B = $C_{16}H_{18}N_2$, Diphenylpiperazine (25)

% B	n_C^{22}	d_4^{22}
0.00	1.49484	0.87605
3.64	1.49915	0.88315
4.78	1.50028*	0.88517*

* t = 21°C.

392. B = $C_{16}H_{20}N_2$, *sym.*-Diphenyldimethylethylenediamine (25)

0.00	1.49484	0.87605
10.30	1.50536	0.89334
11.46	1.50719*	0.89594*

* t = 21.5°C.

393. B = $C_{18}H_{22}N_2$, Dibenzylpiperazine (25)

0.00	1.49484	0.87605
11.09	1.50221	0.89215
13.52	1.50360	0.89536

394. B = $C_{27}H_{44}$, α-Cholesterylene (24)

% B	n_D^{20}	d_4^{20}
0.000	1.50093	0.87862
6.639	1.50207	0.88340
10.412	1.50290	0.88612

395. B = $C_{27}H_{46}$, Cholestene (24)

0.000	1.50093	0.87862
10.104	1.50113	0.88426
17.979	1.50182	0.88912

396. B = $C_{27}H_{46}O$, Cholesterol (24)

% B	n_D^{20}	d_4^{20}
0.000	1.50093	0.87862
6.018	1.50165	0.88420
6.628	1.50170	0.88476

397. B = $C_{27}H_{48}$, Cholestane (24)

0.000	1.50093	0.87862
6.151	1.50076	0.88164

398. B = $C_{29}H_{48}OS_2$, Methyl cholesterylxanthogenate (24)

0.000	1.50093	0.87862
6.772	1.50366	0.88830
11.355	1.50561	0.89506

399. B = $C_{29}H_{50}OS_2$, Methyl dihydrocholesterylxanthogenate (24)

0.000	1.50093	0.87862
10.987	1.50482	0.89386
15.665	1.50663	0.90056

See also 235, 284, 308, 312, 324, 350, 376, 552, 557.

$C_6H_6N_2O_2$

o-Nitroaniline; *see* 351

$C_6H_6N_2O_2$

p-Nitroaniline; *see* 352

C_6H_6O

Phenol; *see* 48

$C_6H_6O_3S$

Benzenesulfonic acid; *see* 285

C_6H_7N

Aniline

400. B = C_9H_7N, Quinoline (76)

% A	n_D^t	d_4^t	t
0.000	1.62694	1.0929	20.7
9.709	1.62455	1.0870	20.9
16.679	1.62250	1.0827	20.8
100.000	1.58592	1.0217	20.7

401. B = $C_{10}H_8$, Naphthalene (76)

% B	n_D^t	d_4^t	t
0.000	1.58857	1.0248	16.5
9.998	1.59116	1.0239	17.2
20.037	1.59418	1.0234	17.8

402. B = $C_{10}H_9N$, α-Naphthylamine (76)

0.000	1.58552	1.2632*	21.1
10.880	1.59548	1.0301	21.1

See also 49, 313, 325, 379, 382.

* This is obviously wrong.

$C_6H_8O_2$

Cyclohexan-1, 4-dione; *see* 326

$C_6H_8O_7$

Citric acid; *see* 50, 544, 565, 566

$C_6H_{10}O$

Cyclohexanone

403. B = $C_{10}H_8$, Naphthalene (76)

% B	n_D^t	d_4^t	t
0.000	1.45171	0.9488	17.9
12.678	1.47227	0.9590	17.8
22.190	1.48788	0.9669	17.6

$C_6H_{10}O_4$

Diethyl oxalate; *see* 252

C_6H_{12}

Cyclohexane

404. B = $C_7H_7NO_2$, *m*-Nitrotoluene (33)

% B	n_D^t	d_4^t
	t = 15°C	
0.0	1.42890	0.7830
29.8	1.45329	0.8662
50.0	1.47498	0.9347
70.4	1.50194	1.0158
86.8	1.52614	1.0923
100.0	1.54919	1.1630
	t = 30°C	
0.0	1.42206	0.7696
29.8	1.44718	0.8525
50.0	1.46861	0.9198
70.4	1.49553	1.0014
86.8	1.51974	1.0776
100.0	1.54263	1.1483

405. B = C_7H_9N, *m*-Toluidine (33)

	t = 15°C	
0.0	1.42890	0.7830
24.1	1.45480	0.8249
45.7	1.48171	0.8669
61.7	1.50582	0.9015
82.4	1.53791	0.9509
100.0	1.57068	0.9970
	t = 30°C	
0.0	1.42206	0.7696
24.1	1.44821	0.8117
45.7	1.47513	0.8538
61.7	1.49921	0.8886
82.4	1.53145	0.9382
100.0	1.56381	0.9848

$C_6H_{12}O_2$

Isobutyl acetate

406. B = $C_7H_{14}O_2$, Ethyl isovalerate; t = 20°C (92)

% B	n_D^t
0.0000	1.54444
18.7251	1.54552
31.3151	1.54622
48.3989	1.54734
64.4828	1.54824
77.1855	1.54894
100.0000	1.55026

$100n = n_A(\% A) + n_B(\% B) \pm 0.0001$.

$C_6H_{12}O_2$

Ethyl butyrate

407. B = $C_6H_{12}O_2$, Ethyl isobutyrate; t = 20°C (92)

% B	n_D^t
0.0000	1.54624
25.4236	1.54511
49.0035	1.54403
74.2817	1.54298
100.0000	1.54181

$100n = n_A(\% A) + n_B(\% B) \pm 0.0001$.

$C_6H_{12}O_2$

Ethyl isobutyrate; *see* 407

$C_6H_{12}O_6$

Fructose; *see* 51

$C_6H_{12}O_6$

Glucose; *see* 52

C_6H_{14}

Hexane

408. B = $C_7H_7NO_2$, *m*-Nitrotoluene (33)

% B	n_D^t	d_4^t
	t = 15°C	
0.0	1.37805	0.6680
28.3	1.41154	0.7614
53.1	1.44886	0.8658
69.7	1.48286	0.9522
86.6	1.51770	1.0591
100.0	1.54919	1.1630
	t = 30°C	
0.0	1.37025	0.6545
28.3	1.40451	0.7468
53.1	1.44263	0.8513
69.7	1.47650	0.9368
86.6	1.51132	1.0422
100.0	1.54263	1.1483

409. B = C_7H_9N, *m*-Toluidine (33)

	t = 22°C	
0.0	1.37441	0.6617
27.7	1.41346	0.7277
44.9	1.44278	0.7761
63.1	1.47860	0.8361
83.1	1.52395	0.9138
100.0	1.56746	0.9913
	t = 32°C	
0.0	1.36921	0.6527
27.7	1.40928	0.7188
44.9	1.43916	0.7673
63.1	1.47493	0.8273
83.1	1.51973	0.9053
100.0	1.56289	0.9832

$C_6H_{14}O_6$

Dulcitol; *see* 53

$C_6H_{14}O_6$

d-Mannitol; *see* 54

$C_6H_{14}O_6$

d-Sorbitol; *see* 55

$C_6H_{15}N$

Triethylamine; *see* 56

$C_6H_{17}N_3O_7$

Ammonium citrate; *see* 57

$C_7H_5NO_4$

o-Nitrobenzoic acid; *see* 290

$C_7H_5NO_4$

m-Nitrobenzoic acid; *see* 291

$C_7H_5NO_4$

p-Nitrobenzoic acid; *see* 292

C_7H_5NS

Phenyl isothiocyanate; *see* 371

C_7H_5NS

Phenyl thiocyanate; *see* (154)

$C_7H_5N_3O_6$

2, 4, 6-Trinitrotoluene; *see* 587

$C_7H_6N_2O_4$

2, 4-Dinitrotoluene; *see* 587

$C_7H_6N_2O_4$

o-Nitrophenylnitromethane; *see* 295

$C_7H_6N_2O_4$

p-Nitrophenylnitromethane; *see* 296

C_7H_6O

Benzaldehyde

410. B = C_9H_7N, Quinoline (76)

% A	n_D^t	d_4^t	t
0.000	1.63025	1.0979	14.9
17.090	1.61565	1.0899	14.8

$C_7H_6O_2$

Benzoic acid

411. B = C_9H_7N, Quinoline (76); *see also* 297

0.000	1.62626	1.0930	19.1
40.079	1.60326	1.1388	19.1
0.000	1.62517	1.0911	21.6
13.418	1.61740	1.1061	21.6
45.882	1.59883	1.1433	21.5
0.000	1.62395	1.0890	25.0
10.202	1.61838	1.1007	24.6

C_7H_7Br

Benzyl bromide

412. B = C_7H_7Cl, Benzyl chloride; t = 20°C (92)

% B	n_D^t
0.0000	1.52505
18.8772	1.53165
23.3439	1.53347
33.0428	1.53669
48.0849	1.54197
65.3828	1.54820
73.9944	1.55130
78.9757	1.55295
100.0000	1.56042

$100n = n_A(\% A) + n_B(\% B) \pm 0.0002$.

C_7H_7Cl

Benzyl chloride; *see* 412

$C_7H_7NO_2$

m-Nitrotoluene

413. B = C_7H_8, Toluene (33)

% B	n^t_{5893}	d^t_4
t = 15°C		
0.0	1.54919	1.1630
14.4	1.54052	1.1095
30.7	1.53160	1.0544
49.6	1.52177	0.9970
72.7	1.51131	0.9353
100.0	1.49985	0.8715
t = 30°C		
0.0	1.54263	1.1483
14.4	1.53388	1.0948
30.7	1.52451	1.0398
49.6	1.51468	0.9825
72.7	1.50366	0.9210
100.0	1.49178	0.8576

414. B = C_7H_{14}, Methylcyclohexane (33)

% B	n^t_{5893}	d^t_4
t = 15°C		
0.0	1.54919	1.1630
15.3	1.52368	1.0792
32.3	1.49887	0.9988
51.8	1.47368	0.9208
73.9	1.44845	0.8465
100.0	1.42535	0.7734
t = 30°C		
0.0	1.54263	1.1483
15.3	1.51746	1.0646
32.3	1.49261	0.9845
51.8	1.46766	0.9069
73.9	1.44214	0.8330
100.0	1.41864	0.7603

See also 404, 408.

$C_7H_7NO_2$

p-Nitrotoluene; *see* 587

C_7H_8

Toluene; *cf.* (75)

415. B = C_7H_9N, *m*-Toluidine (33)

% B	n^t_{5893}	d^t_4
t = 15°C		
0.0	1.49985	0.8715
19.0	1.51203	0.8928
45.9	1.53043	0.9247
65.4	1.54443	0.9495
82.4	1.55698	0.9722
100.0	1.57068	0.9970
t = 30°C		
0.0	1.49178	0.8756
19.0	1.50430	0.8790
45.9	1.52279	0.9114
65.4	1.53715	0.9365
82.4	1.54991	0.9595
100.0	1.56381	0.9848

416. B = $C_{12}H_{12}O_2$, 2-Benzoylcyclopentanone (9)

% B	n^t_D	d^t_4	t
0.000	1.49515	0.86002	25.0
5.895	1.50123	0.8717	25.2

417. B = $C_{13}H_{14}O_2$, 2-Benzoylcyclohexanone (9)

% B	n^t_D	d^t_4	t
0.000	1.49515	0.86002	25.0
3.607	1.49733	0.86796	25.0
8.002	1.49974	0.87755	25.0

See also 236, 304, 314, 327, 413, 586.

C_7H_8O

m-Cresol

418. B = C_9H_7N, Quinoline (76)

% B	n^t_D	d^t_4	t
0.000	1.54135	1.0338	20.4
88.167	1.61989	1.0908	19.0
88.584	1.61977	1.0897	20.4
100.000	1.62724	1.0935	20.0
100.000	1.62724	1.0931	20.5

419. B = $C_{10}H_8$, Naphthalene (76)

0.000	1.54246	1.0363	18.0
9.556	1.55019	1.0351	18.0
13.000	1.55278	1.0349	18.0

C_7H_8O

Anisole

420. B = C_9H_7N, Quinoline (76)

80.358	1.61146	1.0835	8.0
84.809	1.61273	1.0821	15.0
100.000	1.63342	1.1024	8.8
100.000	1.63007	1.0977	15.0

421. B = $C_{10}H_8$, Naphthalene (76)

0.000	1.51950	0.9989	16.5
11.013	1.53103	1.0018	16.6
19.089	1.53951	1.0043	16.8

C_7H_9N

o-Toluidine

422. B = C_9H_7N, Quinoline; t = 20.7°C (76)

% B	n^t_D	d^t_4
0.000	1.57222	0.9977
90.527	1.62299	1.0849
100.000	1.62694	1.0929

423. B = $C_{10}H_9N$, α-Naphthylamine; t = 20.7°C (76)

0.000	1.57222	0.9977
10.926	1.58351	1.0100

C_7H_9N

m-Toluidine

424. B = C_7H_{14}, Methylcyclohexane (33)

% B	n^t_D	d^t_4
t = 15°C		
0.0	1.57068	0.9970
18.6	1.53797	0.9456
37.9	1.50771	0.8979
57.9	1.47802	0.8528
78.1	1.45025	0.8125
100.0	1.42535	0.7734

424.—(*Continued*)

% B	n^t_D	d^t_4
t = 30°C		
0.0	1.56381	0.9848
18.6	1.53148	0.9332
37.9	1.50141	0.8852
57.9	1.47151	0.8399
78.1	1.44400	0.7995
100.0	1.41864	0.7603

See also 384, 405, 409, 415.

$C_7H_9NO_2$

Ammonium benzoate; *see* 58

$C_7H_9NO_3$

Ammonium salicylate; *see* 59

$C_7H_{12}O_6$

Quinic acid; *see* 60, 567

C_7H_{14}

Methylcyclohexane; *see* 414, 424

$C_7H_{14}O_2$

Ethyl isovalerate; *see* 406

$C_7H_{14}O_6$

α-Methylglucoside; *see* 61

$C_7H_{14}O_6$

β-Methylglucoside; *see* 61

C_7H_{16}

Heptane

425. B = $C_{10}H_7Br$, α-Bromonaphthalene (105)

% B	n^{15}_F	d^t_{15}	t
69.46	1.54312	1.10062	15

See also 318, 385.

C_8H_7N

Benzyl cyanide

426. B = $C_8H_{10}O$, Phenetole (105)

% B	n^{15}_F	d^t_{15}	t
0.00	1.53625	1.02025*	15.2
48.73	1.52917	0.99653	15.0
100.00	1.52197	0.96963*	14.7

* d^t_4.

C_8H_8O

Acetophenone

427. B = C_9H_7N, Quinoline (76)

% B	n^t_D	d^t_4	t
77.932	1.60876	1.0831	14.8
100.000	1.63025	1.0979	14.9

428. B = $C_{10}H_8$, Naphthalene (76)

0.000	1.53660	1.0308	14.9
13.423	1.54866	1.0311	14.9
14.198	1.54941	1.0311	14.9

429. B = $C_{10}H_9N$, α-Naphthylamine (76)

0.000	1.53355	1.0249	20.7
0.936	1.54893	1.0352	20.7

$C_8H_8O_2$

Phenylacetic acid; *see* 62, 568

$C_8H_8O_3$

Phenylglycolic acid; *see* 63, 569

C_8H_9Br

Bromo-*p*-xylene

430. B = C_9H_7N, Quinoline (76)

% B	n^t_D	d^t_4	t
83.285	1.61978	1.1350	15.2
100.000	1.63011	1.0979	15.2

C_8H_{10}

Ethylbenzene

431. B = C_8H_{10}, *o*-Xylene (92)

% B	n^{20}_D
0.000	1.50497
24.1074	1.50283
50.1866	1.50058
75.2146	1.49847
100.0000	1.49659

a = 1.50497, b = −0.0905, c = 0.062; ϵ = 1.

432. B = C_8H_{10}, *m*-Xylene (92)

0.000	1.49843
24.6565	1.49786
50.3372	1.49728
78.8580	1.49673
100.000	1.49659

a = 1.49843, b = −0.0276, c = 0.092, ϵ = 1.

433. B = C_8H_{10}, *p*-Xylene (92)

0.000	1.49625
25.2055	1.49632
51.1066	1.49635
75.2683	1.49646
100.000	1.49659

n_D is linear in % B; ϵ = 1.

C_8H_{10}

o-Xylene

434. B = C_8H_{10}, *m*-Xylene; t = 20°C (92)

% B	n^t_D
0.000	1.50497
24.6677	1.50333
49.5001	1.50168
74.7756	1.50006
100.0000	1.49843

n_D is linear in % B; ϵ = 1.

435. B = C_8H_{10}, *p*-Xylene; t = 20°C (92)

0.000	1.50497
24.9410	1.50292
49.4932	1.50075
74.7171	1.49852
100.000	1.49625

n_D is linear in % B; ϵ = 1.

See also 367, 431.

C_8H_{10}

m-Xylene

436. B = C_8H_{10}, *p*-Xylene; t = 20°C (92)

% B	n_D^t
0.000	1.49840
24.9807	1.49828
50.2550	1.49772
75.0229	1.49712
100.000	1.49625

a = 1.49840, b = −0.0013, c = −0.202; ϵ = 1.

See also 432, 434.

C_8H_{10}

p-Xylene; *see* 433, 435, 436

$C_8H_{10}N_2O$

p-Nitrosodimethylaniline (31)

$C_8H_{10}O$

Phenetole; *see* 426

$C_8H_{14}O_6$

Diethyl tartrate; *see* 368, 369

$C_8H_{18}O$

1-β-Octanol; *see* 386

$C_9H_6Br_2O_2$

Dibromocinnamic acid; *see* 328

$C_9H_7BrO_2$

α-Bromocinnamic acid; *see* 329

$C_9H_7BrO_2$

β-Bromocinnamic acid; *see* 330

$C_9H_7BrO_2$

α-Bromoallocinnamic acid; *see* 331

$C_9H_7BrO_2$

β-Bromoallocinnamic acid; *see* 332

$C_9H_7ClO_2$

α-Chlorocinnamic acid; *see* 333

$C_9H_7ClO_2$

α-Chloroallocinnamic acid; *see* 334

C_9H_7N

Quinoline

437. B = $C_9H_8N_2O$, 2-Acetylindazole (76)

% B	n_D^t	d_4^t	t
0.000	1.62728	1.0932	20.4
10.013	1.62378	1.1018	20.0

438. B = $C_9H_{10}O_2$, *o*-Ethylbenzoic acid (76)

0.000	1.62799	1.0944	19.1
0.000	1.62724	1.0938	19.8
10.659	1.61973	1.0984	19.8
11.817	1.61936	1.0995	19.1
46.712	1.59482	1.1152	18.9
100.000	1.51012	1.0420	99.6
100.000	1.50993	1.0413	100.0

439. B = $C_9H_{10}O_2$, Ethyl benzoate (76)

% B	n_D^t	d_4^t	t
0.000	1.63342	1.1024	8.8
14.974	1.61483	1.0965	8.4

440. B = C_9H_{12}, *p*-Methylethylbenzene (76)

0.000	1.63226	1.1018	9.6
0.000	1.63006	1.0981	14.5
18.346	1.60286	1.0496	14.4
53.375	1.57714*	0.9886	8.6
100.000	1.49896	0.8667	14.6

* The first 7 is probably a misprint.

441. B = $C_{10}H_6Cl_2$, 1, 4-Dichloronaphthalene (76)

0.000	1.62954	1.0979	15.0
14.297	1.63161	1.1276	15.0

442. B = $C_{10}H_6Cl_2$, 1, 5-Dichloronaphthalene (76)

0.000	1.62872	1.0972	15.7
8.541	1.62986	1.1148	15.8
9.835	1.63021	1.1175	15.6

Max. solubility is *ca.* 13 % B.

443. B = $C_{10}H_6Cl_2$, 1, 7-Dichloronaphthalene (76)

0.000	1.62854	1.0968	16.1
9.195	1.62990	1.1153	15.8
28.217	1.63237	1.1542	16.0
100.000	1.60921	1.2611	99.5

444. B = $C_{10}H_6Cl_2$, 1, 8-Dichloronaphthalene (76)

0.000	1.62877	1.0958	17.4
10.086	1.63110	1.1176	17.4
38.683	1.63811	1.1840	17.4
100.000	1.62357	1.2924	99.8

445. B = $C_{10}H_6Cl_2$, 2, 7-Dichloronaphthalene (76)

0.000	1.62845	1.0970	15.9
9.984	1.62968	1.1159	15.9
10.510	1.62973	1.1170	15.9

446. B = $C_{10}H_7Cl$, β-Chloronaphthalene (76)

0.000	1.62945	1.0977	15.3
10.011	1.62985	1.1058	15.3

447. B = $C_{10}H_7I$, α-Iodonaphthalene (76)

0.000	1.62775	1.0959	17.2
100.000	1.70540	1.7474	14.0

448. B = $C_{10}H_7I$, β-Iodonaphthalene (76)

0.000	1.62775	1.0959	17.2
16.824	1.63702	1.1675	16.8
100.000	1.66617	1.6319	99.4

449. B = $C_{10}H_8$, Naphthalene (76)

0.000	1.62880	1.0963	16.8
14.438	1.62863	1.0862	16.8
16.104	1.62847	1.0851	16.9

450. B = $C_{10}H_8O$, α-Naphthol (76)

0.000	1.62755	1.0937	19.9
10.971	1.63393	1.1039	19.9
100.000	1.62240	1.0989	99.3

451. B = $C_{10}H_8O$, β-Naphthol (76)

0.000	1.62816	1.0947	18.6
9.841	1.63328	1.1029	18.6
15.571	1.63634	1.1076	18.6

452. B = $C_{10}H_9N$, α-Naphthylamine (76)

% B	n_D^t	d_4^t	t
0.000*	1.62751	1.0936	19.6
9.494	1.63473	1.0976	20.4
9.954	1.63547	1.0982	19.6
17.358	1.64072	1.1007	20.4
100.000*	1.67032	1.0997	51.2
100.000*	1.66932	1.0965	54.1

* Air excluded as well as possible.

453. B = $C_{10}H_9N$, β-Naphthylamine (76)

0.000	1.62577	1.0913	22.8
9.548	1.63383	1.0947	22.8
10.682	1.63449	1.0951	22.9
15.315	1.63828	1.0964	22.8
16.808	1.63927	1.0969	22.9

454. B = $C_{10}H_{10}N_2$, 1, 4-Naphthylenediamine (76)

0.000	1.62881	1.0958	17.8
11.352*	1.64414	1.1104	17.8

* Darkened by oxidation.

455. B = $C_{10}H_{10}N_2$, 1, 5-Naphthylenediamine (76)

0.000	1.62966	1.0979	14.4
8.408	1.64301	1.1104	13.8
9.646	1.64462	1.1117	14.4

456. B = $C_{10}H_{10}N_2$, 1, 6-Naphthylenediamine (76)

0.000	1.62657	1.0933	19.3
10.189	1.64149	1.1067	19.3
14.498	1.64752	1.1120	19.3
100.000	1.70831	1.1472	99.4

457. B = $C_{10}H_{10}N_2$, 1, 8-Naphthylenediamine (76)

0.000	1.62608	1.0928	19.3
9.125	1.63681	1.1028	19.2
28.692	1.65770	1.1221	19.2
100.000*	1.68278	1.1265	99.4

* Darkened as soon as placed in cell.

458. B = $C_{10}H_{10}N_2$, 2, 3-Naphthylenediamine (76)

0.000	1.62395	1.0890	25.0
0.000	1.62256	1.0863	28.4
7.476	1.63390	1.0969	26.0
8.029	1.63426	1.0968	27.2

459. B = $C_{10}H_{10}N_2$, 2, 7-Naphthylenediamine (76)

0.000	1.63040	1.0995	13.0
0.000	1.62846	1.0962	17.1
9.581	1.64465	1.1120	12.5
9.652	1.64289	1.1085	17.0

460. B = $C_{10}H_{14}$, *p*-Cymene (76)

0.000	1.63058	1.0988	13.4
0.000	1.63007	1.0979	15.2
16.046	1.60566	1.0552	13.2
18.486	1.60138	1.0474	15.1
52.013	1.55396	0.9656	12.9
100.000	1.49271	0.8605	16.1

461. B = $C_{10}H_{14}O$, *p*-Tolyldimethyl carbinol (76)

0.000	1.63072	1.0985	13.8
19.223	1.60933	1.0774	13.7
100.000	1.52215	0.9844	13.5

462. B = $C_{11}H_8O$, α-Naphthaldehyde (76)

0.000	1.62539	1.0914	21.2
14.012	1.62920	1.0989	21.3
44.593	1.63748	1.1156	21.0
100.000	1.65464	1.1490	19.3

463. B = $C_{11}H_8O$, β-Naphthaldehyde (76)

% B	n_D^t	d_4^t	t
0.000	1.62597	1.0925	21.0
28.679	1.63272	1.1018	20.7
100.00	1.62107	1.0775	99.4

464. B = $C_{11}H_{12}O$, 1-Keto-7-methyl-1, 2, 3, 4-tetrahydronaphthalene (76)

0.000	1.62917	1.0965	16.9
33.830	1.60647	1.0876	17.0
100.000	1.55674	1.0569	35.0

465. B = $C_{12}H_8O$, Diphenylene oxide (76)

0.000	1.63072	1.0989	13.5
12.824	1.63302	1.1063	13.6

466. B = $C_{12}H_{10}$, Diphenyl (76)

0.000	1.63093	1.0992	13.4
17.311	1.62948	1.0891	13.1

467. B = $C_{12}H_{12}O$, β-Naphthyl ethyl ether (76)

0.000	1.62923	1.0976	15.4
10.607	1.62707	1.0939	15.4

468. B = $C_{12}H_{13}N$, α-Ethylaminonaphthalene (76)

0.000	1.62788	1.0957	17.4
9.130	1.63114	1.0938	17.2
48.730	1.64280	1.0836	16.6
100.000	1.64773	1.0652	15.1

469. B = $C_{12}H_{13}N$, β-Ethylaminonaphthalene (76)

0.000	1.62541	1.0902	24.1
11.512	1.63032	1.0868	23.6
46.552	1.64273	1.0745	23.7
100.000*	1.65175	1.0524	25.3
100.000†	1.65440	1.0545	21.3

* Prepared from pure acetyl compound.

† Purified by recrystallization of hydrochloride.

470. B = $C_{13}H_7Cl_3$, Trichlorofluorene (76)

0.000	1.63212	1.1005	11.5
0.000	1.62917	1.0956	17.6
9.479	1.63242	1.1208	18.0
9.735	1.63567	1.1267	11.6
9.906	1.63230	1.1215	18.5

471. B = $C_{13}H_8Br_2$, 2, 7-Dibromofluorene (76)

0.000	1.62679	1.0913	22.9
0.000	1.62455	1.0878	27.2
9.201	1.63084	1.1293	24.1
9.532	1.62964	1.1287	26.8
10.776	1.63082	1.1351	26.0

472. B = $C_{13}H_8O$, Fluorenone (76)

0.000	1.62924	1.0965	16.7
10.846	1.63349	1.1056	16.9

473. B = $C_{13}H_{10}$, Fluorene (76)

0.000	1.62924	1.0965	16.7
9.171	1.63092	1.0954	16.8

474. B = $C_{13}H_{12}$, Diphenylmethane (76)

0.000	1.62986	1.0974	15.7
17.968	1.62099	1.0820	15.6

475. B = $C_{13}H_{12}O$, 1-Methyl-2-acetylnaphthalene (76)

0.000	1.62819	1.0967	16.5
43.769	1.62743	1.0999	16.4
100.000	1.62695	1.1046	16.1

$\mathbf{C_9H_7N}$.—(*Continued*)

476. B = $\mathbf{C_{13}H_{12}O_2}$, Ethyl β-naphthoate (76)

% B	n_D^t	d_4^t	t
0.000	1.62926	1.0975	15.6
10.530	1.62601	1.0998	15.6

477. B = $\mathbf{C_{13}H_{14}}$, 1-Methyl-2-ethylnaphthalene (76)

0.000	1.62837	1.0970	16.0
64.421	1.61066	1.0338	15.7
100.000	1.60138	1.0014	15.4

478. B = $\mathbf{C_{14}H_8Br_2}$, 9, 10-Dibromoanthracene (76)

0.000	1.59096	1.0309	99.5
0.000	1.59087	1.0310	99.6
9.114	1.60060	1.0697	99.7
9.776	1.60137	1.0724	99.6

479. B = $\mathbf{C_{14}H_8Cl_2}$, 1, 4-Dichloroanthracene (76)

0.000	1.59110	1.0310	99.0
0.000	1.59105	1.0311	99.1
9.064	1.59937	1.0498	99.2
9.678	1.60000	1.0510	99.0

480. B = $\mathbf{C_{14}H_8Cl_2}$, 1, 5-Dichloroanthracene (76)

0.000	1.59090	1.0305	99.3
0.000	1.59082	1.0308	99.4
8.278	1.59854	1.0477	99.3
10.255	1.60037	1.0520	99.4

481. B = $\mathbf{C_{14}H_8Cl_2}$, 9, 10-Dichloroanthracene (76)

0.000	1.59077	1.0310	99.3
0.000	1.59072	1.0311	99.3
9.828	1.60113	1.0535	99.2
9.972	1.60141	1.0535	99.3

482. B = $\mathbf{C_{14}H_8Cl_2}$, 9, 10-Dichlorophenanthrene (6)

% B	n_{5876}^t	d_4^t	t
0.000	1.62271	1.0875	25.4
6.644	1.62733	1.1032	25.6
5.981	1.62733	1.1023	25.5

483. B = $\mathbf{C_{14}H_9Cl}$, α-Chloroanthracene (76)

% B	n_D^t	d_4^t	t
0.000	1.62924	1.0962	17.0
0.000	1.62821	1.0947	18.9
0.000	1.59032	1.0302	100.3
11.891	1.60214	1.0452	99.7
13.780	1.64149	1.1111	18.8
19.448	1.64797	1.1194	16.7
100.000	1.69589	1.1707	99.5

484. B = $\mathbf{C_{14}H_9Cl}$, β-Chloroanthracene (76)

0.000	1.59078	1.0306	99.7
9.258	1.60000	1.0422	99.6
10.346	1.60110	1.0435	99.7

485. B = $\mathbf{C_{14}H_9Cl}$, 9-Chloroanthracene (76)

0.000	1.63072	1.0984	14.1
0.000	1.63054	1.0985	14.4
11.713	1.64183	1.1139	14.4
12.214	1.64317	1.1148	14.1

486. B = $\mathbf{C_{14}H_9Cl}$, 9-Chlorophenanthrene (6)

486.—(*Continued*)

% B	n_{5876}^t	d_4^t	t
0.000	1.62315	1.0888	25.6
9.986	1.62963	1.1032	25.7
10.714	1.62821	1.1019	25.7
100.000	1.67393	1.2167	100.5

487. B = $\mathbf{C_{14}H_{10}}$, Anthracene (76)

% B	n_D^t	d_4^t	t
0.000	1.59078	1.0307	99.4
9.822	1.60087	1.0325	99.5
10.950	1.60187	1.0335	99.5

488. B = $\mathbf{C_{14}H_{10}}$, Phenanthrene (76)

0.000	1.62990	1.0972	15.6
10.653	1.63749	1.0997	15.7
25.995	1.64835	1.1032	15.7
100.000	1.68588	1.0412*	129.6

* t = 131°C.

489. B = $\mathbf{C_{14}H_{10}Br_2}$, 2, 7-Dibromo-9-methylfluorene (76)

0.000	1.63118	1.0985	13.8
10.013	1.63574	1.1391	13.7
17.244	1.63899	1.1699	13.8

490. B = $\mathbf{C_{14}H_{12}}$, 9, 10-Dihydroanthracene (76)

0.000	1.62911	1.0959	17.3
13.749	1.62774	1.0946	17.2
18.578	1.62743	1.0944	17.0

491. B = $\mathbf{C_{14}H_{12}}$, Dihydrophenanthrene (6)

% B	n_{5876}^t	d_4^t	t
0.000	1.62323	1.0906	24.6
9.319	1.62979	1.0940	24.5
9.911	1.63015	1.0942	24.5

492. B = $\mathbf{C_{14}H_{12}}$, Stilbene (6)

0.000	1.62577	1.0943	20.5
9.673	1.63134	1.0888	19.9
9.709	1.63108	1.0883	21.7

493. B = $\mathbf{C_{14}H_{14}O}$, 1-Ethyl-4-acetylnaphthalene (76)

% B	n_D^t	d_4^t	t
0.000	1.62819	1.0971	16.0
39.667	1.62446	1.0950	16.0
100.000	1.61979	1.0922	15.7

494. B = $\mathbf{C_{14}H_{15}NO}$, α-Acetylethylaminonaphthalene (76)

0.000	1.62649	1.0931	20.2
12.087	1.62276	1.0933	20.3
100.000	1.59471	1.0888	27.3
100.000	1.56440	1.0359	99.0

495. B = $\mathbf{C_{14}H_{15}NO}$, β-Acetylethylaminonaphthalene (76)

0.000	1.62473	1.0899	24.1
9.873	1.62252	1.0903	23.5
48.278	1.61320	1.0900	23.5
100.000	1.60312	1.0893	23.1

496. B = $\mathbf{C_{14}H_{17}N}$, α-Diethylaminonaphthalene (76)

0.000	1.62833	1.0953	18.0
10.258	1.62509	1.0861	18.0
44.072	1.61369	1.0565	18.0
100.000	1.59331	1.0071	18.1

497. B = $\mathbf{C_{14}H_{17}N}$, β-Diethylaminonaphthalene (76)

497.—(*Continued*)

% B	n_D^t	d_4^t	t
0.000	1.62539	1.0915	22.1
10.871	1.62685	1.0840	21.8
46.652	1.63008	1.0600	21.9
100.000	1.63210	1.0242	21.6

498. B = $\mathbf{C_{14}H_{17}N}$, 1, 4-Diethylaminonaphthalene (76)

0.000	1.63054	1.0987	14.2
23.080	1.61905	1.0753	14.2
100.000	1.53943	0.9318	99.6

499. B = $\mathbf{C_{14}H_{17}N}$, 2, 3-Diethylaminonaphthalene (76)

0.000	1.62569	1.0917	20.6
10.137	1.62219	1.0809	20.7
16.494	1.62014	1.0748	20.8
100.000	1.55589	0.9371	99.3

500. B = $\mathbf{C_{14}H_{24}N_2}$, Tetraethyl-*o*-phenylenediamine (76)

0.000	1.63192	1.1010	10.7
19.935	1.60944	1.0653	10.6
100.000	1.52134	0.9267	12.6

501. B = $\mathbf{C_{14}H_{24}N_2}$, Tetraethyl-*m*-phenylenediamine (76)

0.000	1.63176	1.1007	11.2
13.739	1.62174	1.0804	10.8
46.892	1.59629	1.0303	11.0
100.000	1.55367	0.9522	11.8

502. B = $\mathbf{C_{14}H_{24}N_2}$, Tetraethyl-*p*-phenylenediamine (76)

0.000	1.63192	1.1010	10.7
14.310	1.62032	1.0788	10.4
100.000	1.50551	0.8795	99.3

503. B = $\mathbf{C_{15}H_{10}}$, Fluoranthene (6)

% B	n_{5876}^t	d_4^t	t
0.000	1.62647	1.0942	18.6
9.974	1.63693	1.0996	18.7
0.000*	1.62778	1.0969	15.8
14.023*	1.64269	1.1045	15.2

* A second preparation.

504. B = $\mathbf{C_{15}H_{11}Cl}$, 1-Methyl-4-chloroanthracene (76)

% B	n_D^t	d_4^t	t
0.000	1.62920	1.0959	17.2
13.007	1.63971	1.1108	17.2
16.596	1.64259	1.1152	17.2

505. B = $\mathbf{C_{15}H_{12}}$, α-Methylanthracene (76)

0.000	1.63033	1.0980	14.5
0.000	1.62985	1.0973	15.6
9.213	1.63839	1.0975	15.3
16.901	1.64587	1.0983	14.4
17.059	1.64570	1.0978	15.1
100.000	1.68027	1.0471	99.4

506. B = $\mathbf{C_{15}H_{12}}$, β-Methylanthracene (76)

0.000	1.59073	1.0308	99.1
0.000	1.59087	1.0310	99.5
8.604	1.59855	1.0303	99.6
9.409	1.59914	1.0307	99.3

507. B = $\mathbf{C_{15}H_{12}}$, 9-Methylanthracene (76)

% B	n_D^t	d_4^t	t
0.000	1.63011	1.0980	14.9
0.000	1.62916	1.0964	17.0
9.851	1.64030	1.0997	14.7
10.518	1.64006	1.0987	16.7
100.000	1.69589	1.0657	99.4

508. B = $\mathbf{C_{15}H_{12}O}$, Anthranol methyl ether (76)

0.000	1.62938	1.0960	17.2
10.801	1.63833	1.1014	17.2
17.879	1.64417	1.1050	17.2
100.000	1.67855	1.0941	99.3

509. B = $\mathbf{C_{15}H_{14}}$, *m*-Methylstilbene (76)

0.000	1.63009	1.0982	14.5
13.297	1.63495	1.0879	14.7

510. B = $\mathbf{C_{16}H_{10}}$, Pyrene (6)

% B	n_{5876}^t	d_4^t	t
0.000	1.62726	1.0949	17.1
13.783	1.64528	1.1052	17.0
0.000*	1.62647	1.0942	18.6
9.789*	1.63927	1.1012	18.8

* A second preparation.

511. B = $\mathbf{C_{16}H_{13}Cl}$, 9-Ethyl-10-chloroanthracene (76)

% B	n_D^t	d_4^t	t
0.000	1.63137	1.0993	13.0
0.000	1.63076	1.0981	14.2
10.527	1.64092	1.1112	12.6
11.080	1.64067	1.1107	14.2

512. B = $\mathbf{C_{16}H_{16}O}$, Ethylhydroanthranol (76)

0.000	1.62968	1.0966	16.3
0.000	1.62924	1.0962	17.0
18.203	1.62664	1.1041	16.8
24.909	1.62576	1.1073	16.2

513. B = $\mathbf{C_{17}H_{14}Br_2O_2}$, Ethyl 2, 7-dibromofluorene-9-acetate (76)

0.000	1.63133	1.0990	13.4
16.726	1.63340	1.1606	13.3
100.000	1.61300	1.5121	99.8

514. B = $\mathbf{C_{18}H_{18}}$, Retene (6)

% B	n_{5876}^t	d_4^t	t
0.000	1.62655	1.0949	17.9
10.550	1.63009	1.0908	17.5
0.000*	1.62280	1.0886	25.6
11.718*	1.62662	1.0841	25.6

* A second preparation.

515. B = $\mathbf{C_{20}H_{28}O_2}$, 1, 5-Dihydroxynaphthalene diamyl ether (76)

% B	n_D^t	d_4^t	t
0.000	1.62620	1.0918	22.2
11.097	1.61678	1.0799	22.3
19.983	1.60931	1.0710	22.3
100.000	1.51602	0.9411	99.9

See also 298, 377, 400, 410, 411, 418, 420, 422, 427, 430.

$C_9H_8N_2O$

2-Acetylindazole; *see* 437

$C_9H_{10}O_2$

o-Ethylbenzoic acid; *see* 438

$C_9H_{10}O_2$

Ethyl benzoate; *see* 439

C_9H_{12}

p-Methylethylbenzene; *see* 440

$C_{10}H_6Cl_2$

1, 4-Dichloronaphthalene

516. B = $C_{10}H_{12}$, Tetralin (76)

% A	n_D^t	d_4^t	t
0.000	1.54614	0.9729	20.2
12.072	1.55558	1.0062	20.2

517. B = $C_{10}H_{15}N$, Diethylaniline (76)

0.000	1.54392	0.9372	16.7
12.456	1.55404	0.9747	16.7

518. B = $C_{12}H_{14}O_4$, Diethyl phthalate (76)

0.000	1.50444	1.1245	17.7
13.994	1.52121	1.1502	17.6

519. B = $C_{12}H_{16}O_2$, Amyl benzoate (76)

0.000	1.49498	0.9910	17.4
12.770	1.50988	1.0248	18.3

See also 441

$C_{10}H_6Cl_2$

1, 5-Dichloronaphthalene; *see* 442

$C_{10}H_6Cl_2$

1, 7-Dichloronaphthalene; *see* 443

$C_{10}H_6Cl_2$

1, 8-Dichloronaphthalene; *see* 444

$C_{10}H_6Cl_2$

2, 7-Dichloronaphthalene; *see* 445

$C_{10}H_7Br$

α-Bromonaphthalene; *see* 319, 425 (154)

$C_{10}H_7Cl$

β-Chloronaphthalene; *see* 446

$C_{10}H_7I$

α-Iodonaphthalene; *see* 447

$C_{10}H_7I$

β-Iodonaphthalene; *see* 448

$C_{10}H_8$

Naphthalene; *cf.* (42)

520. B = $C_{10}H_{15}N$, Diethylaniline (76)

% A	n_D^t	d_4^t	t
0.0000	1.54619	0.9407	12.3
10.171	1.55423	0.9502	12.9
20.922	1.56287	0.9603	13.2

521. B = $C_{12}H_{14}O_4$, Diethyl phthalate (76)

% A	n_D^t	d_4^t	t
0.000	1.50486	1.1250	16.8
11.274	1.51903	1.1136	17.5
20.912	1.53154	1.1043	17.5

522. B = $C_{12}H_{16}O_2$, Amyl benzoate (76)

0.000	1.49601	0.9930	15.3
17.568	1.51788	0.9996	15.5
18.873	1.51953	1.0000	15.6

523. B = $C_{14}H_{10}$, Anthracene (144)

% B	n_D^t	d_4^t	t
0.000	1.58996	0.9757	85.30
7.976	1.58932	0.9773	90.35

524. B = $C_{14}H_{10}$, Phenanthrene (144)

0.000	1.58996	0.9757	85.30
8.539	1.59427	0.9800	87.65
43.126	1.61844	1.0062	88.42

See also 299, 305, 353, 372, 380, 401, 403, 419, 421, 428, 449.

$C_{10}H_8O$

α-Naphthol; *see* 450

$C_{10}H_8O$

β-Naphthol; *see* 451

$C_{10}H_9N$

α-Naphthylamine

525. B = $C_{10}H_{12}$, Tetralin (76)

% A	n_D^t	d_4^t	t
0.000	1.54605	0.9728	20.6
10.572	1.55893	0.9866	20.7

See also 381, 402, 423, 429, 452.

$C_{10}H_9N$

β-Naphthylamine; *see* 453

$C_{10}H_{10}N_2$

1, 4-Naphthalenediamine; *see* 454

$C_{10}H_{10}N_2$

1, 5-Naphthalenediamine; *see* 455

$C_{10}H_{10}N_2$

1, 6-Naphthalenediamine; *see* 456

$C_{10}H_{10}N_2$

1, 8-Naphthalenediamine; *see* 457

$C_{10}H_{10}N_2$

2, 3-Naphthalenediamine; *see* 458

$C_{10}H_{10}N_2$

2, 7-Naphthalenediamine; *see* 459

$C_{10}H_{12}$

Tetralin; *see* 516, 525

$C_{10}H_{12}O$

Anethole (154)

$C_{10}H_{12}O_2$

Eugenol

526. B = **Oil of cinnamon** (96)

% A	0.0	80.0
t	n_D^t	
19.7		1.5556
29.6	1.5923	1.5508
35.1	1.5902	1.5484
41.1		1.5453

527. B = **Sandalwood oil** (96)

% A	0.0	20.0	40.0
t		n_D^t	
19.7	1.5086	1.5147	1.5208
29.6	1.5048	1.5105	1.5166
35.1	1.5024	1.5083	1.5142
41.1	1.5001	1.5056	1.5117
% A	60.0	80.0	100.0
t		n_D^t	
19.7	1.5276	1.5347	1.5422
29.6	1.5232	1.5304	1.5377
35.1	1.5207	1.5277	1.5351
41.1	1.5182	1.5250	1.5324

If t = 19.7°C, a = 1.5086, b = 0.284, c = 0.52.

If t = 29.6, a = 1.5048, b = 0.275, c = 0.54.

If t = 35.1, a = 1.5024, b = 0.273, c = 0.54.

If t = 41.4, a = 1.5001, b = 0.273, c = 0.5.

In all cases $\epsilon = 1$.

$C_{10}H_{14}$

p-Cymene; *see* 460

$C_{10}H_{14}N_2$

Nicotine; *see* 64

$C_{10}H_{14}O$

p-Tolyldimethyl carbinol; *see* 461

$C_{10}H_{15}BrO$

Bromocamphor; *see* 335, 354, 364, 387

$C_{10}H_{15}N$

Diethylaniline; *see* 517, 520

$C_{10}H_{16}O$

Camphor; *see* 253, 300, 315, 336, 355, 359, 361, 365, 370, 378, 388

$C_{10}H_{18}O$

Borneol; *see* 337, 356, 366, 389

$C_{10}H_{20}O_2$

1-β-Octyl acetate; *see* 390

$C_{11}H_8O$

α-Naphthaldehyde; *see* 462

$C_{11}H_8O$

β-Naphthaldehyde; *see* 463

$C_{11}H_{12}O$

1-Keto-7-methyl-1, 2, 3, 4-tetrahydronaphthalene; *see* 464

$C_{12}H_8O$

Diphenylene oxide; *see* 465

$C_{12}H_{10}$

Diphenyl; *see* 301, 466

$C_{12}H_{10}N_2$

Azobenzene (40, 72)

$C_{12}H_{10}O$

4-Methylnaphthaldehyde (76)

$C_{12}H_{10}O$

Methylnaphthyl ketone (76)

$C_{12}H_{12}O$

β-Naphthyl ethyl ether; *see* 467

$C_{12}H_{12}O_2$

2-Benzoylcyclopentanone; *see* 338, 416

$C_{12}H_{13}N$

α-Ethylaminonaphthalene; *see* 468

$C_{12}H_{13}N$

β-Ethylaminonaphthalene; *see* 469

$C_{12}H_{14}O_4$

Diethyl phthalate; *see* 518, 521

$C_{12}H_{16}O_2$

Amyl benzoate; *see* 519, 522

$C_{12}H_{22}O_{11}$

Lactose; *see* 65

$C_{12}H_{22}O_{11}$

Sucrose (cane sugar); *see* 66 (43)

$C_{13}H_7Cl_3$

Trichlorofluorene; *see* 470

$C_{13}H_8Br_2$

2, 7-Dibromofluorene; *see* 471

$C_{13}H_8O$

Fluorenone; *see* 472

$C_{13}H_{10}$

Fluorene; *see* 473

$C_{13}H_{10}N_4O_6$

α-Methylphenylpicramide; *see* 373

$C_{13}H_{10}N_4O_6$

β-Methylphenylpicramide; *see* 374

$C_{13}H_{10}O_3$

Phenyl salicylate (salol); *see* (90)

$C_{13}H_{12}$

Diphenylmethane; *see* 474

$C_{13}H_{12}O$

1-Methyl-2-acetylnaphthalene; *see* 475

$C_{13}H_{12}O$

2-Methyl-(5)8-acetylnaphthalene (76)

$C_{13}H_{12}O_2$

Ethyl β-naphthoate; *see* 476

$C_{13}H_{13}N$

Benzylaniline (72)

$C_{13}H_{14}$

1-Methyl-2-ethylnaphthalene; *see* 477

$C_{13}H_{14}$

1-Methyl-4-ethylnaphthalene (76)

$C_{13}H_{14}O_2$

2-Benzoylcyclohexanone; *see* 339, 417

$C_{14}H_8Br_2$

9, 10-Dibromoanthracene; *see* 478

$C_{14}H_8Cl_2$

1, 4-Dichloroanthracene; *see* 479

$C_{14}H_8Cl_2$

1, 5-Dichloroanthracene; *see* 480

$C_{14}H_8Cl_2$

9, 10-Dichloroanthracene; *see* 481

$C_{14}H_8Cl_2$

9, 10-Dichlorophenanthrene; *see* 482

$C_{14}H_9Br$

10-Bromophenanthrene (6)

$C_{14}H_9Cl$

α-Chloroanthracene; *see* 483

$C_{14}H_9Cl$

β-Chloroanthracene; *see* 484

$C_{14}H_9Cl$

9-Chloroanthracene; *see* 485

$C_{14}H_9Cl$

9-Chlorophenanthrene; *see* 486

$C_{14}H_{10}$

Anthracene; *see* 487, 523

$C_{14}H_{10}$

Phenanthrene; *see* 488, 524

$C_{14}H_{10}Br_2$

2, 7-Dibromo-9-methylfluorene; *see* 489

$C_{14}H_{12}$

9, 10-Dihydroanthracene; *see* 490

$C_{14}H_{12}$

Dihydrophenanthrene; *see* 491

$C_{14}H_{12}$

Stilbene; *see* 492

$C_{14}H_{14}$

α-Tetrahydrophenanthrene (6)

$C_{14}H_{14}O$

1-Ethyl-4-acetylnaphthalene; *see* 493

$C_{14}H_{15}NO$

α-Acetylethylaminonaphthalene; *see* 494

$C_{14}H_{15}NO$

β-Acetylethylaminonaphthalene; *see* 495

$C_{14}H_{16}$

1, 4-Diethylnaphthalene; *see* (76)

$C_{14}H_{17}N$

α-Diethylaminonaphthalene; *see* 496

$C_{14}H_{17}N$

β-Diethylaminonaphthalene; *see* 497

$C_{14}H_{17}N$

1, 4-Diethylaminonaphthalene; *see* 498

$C_{14}H_{17}N$

1, 5-Diethylaminonaphthalene (76)

$C_{14}H_{17}N$

1, 8-Diethylaminonaphthalene (76)

$C_{14}H_{17}N$

2, 3-Diethylaminonaphthalene; *see* 499

$C_{14}H_{17}N$

2, 6-Diethylaminonaphthalene (76)

$C_{14}H_{17}N$

2, 7-Diethylaminonaphthalene (76)

$C_{14}H_{24}N_2$

Tetraethyl-*o*-phenylenediamine; *see* 500

$C_{14}H_{24}N_2$

Tetraethyl-*m*-phenylenediamine; *see* 501

$C_{14}H_{24}N_2$

Tetraethyl-*p*-phenylenediamine; *see* 502

$C_{15}H_{10}$

Fluoranthrene; *see* 503

$C_{15}H_{11}Cl$

1-Methyl-4-chloroanthracene; *see* 504

$C_{15}H_{12}$

α-Methylanthracene; *see* 505

$C_{15}H_{12}$

β-Methylanthracene; *see* 506

$C_{15}H_{12}$

9-Methylanthracene; *see* 507

$C_{15}H_{12}Br_2$

2, 7-Dibromo-9-ethylfluorene (76)

$C_{15}H_{12}O$

Anthranol methyl ether; *see* 508

$C_{15}H_{14}$

α-Methylstilbene (76)

$C_{15}H_{14}$

m-Methylstilbene; *see* 509

$C_{15}H_{16}O$

1-Methyl-4-ethyl-2-acetylnaphthalene (76)

$C_{15}H_{18}$

1-Methyl-2, 4-diethylnaphthalene (76)

$C_{16}H_{10}$

Pyrene; *see* 510

$C_{16}H_{13}Cl$

9-Ethyl-10-chloroanthracene; *see* 511

$C_{16}H_{14}$

9-Ethylanthracene (76)

$C_{16}H_{14}$

9-Ethylphenanthrene (76)

$C_{16}H_{16}O$

Ethylhydroanthranol; *see* 512

$C_{16}H_{18}N_2$

Diphenylpiperazine; *see* 391

$C_{16}H_{20}N_2$

sym.-Diphenyldimethylethylenediamine; *see* 392

$C_{16}H_{32}O_2$

Palmitic acid

528. B = $C_{18}H_{34}O_2$, Oleic acid (101)

% B	n_D^{60}	n_D^{70}	n_D^{80}
0.00	1.4339	1.4304	1.4269
9.90	1.4357	1.4325	1.4293
22.30	1.4373	1.4342	1.4311
36.50	1.4385	1.4355	1.4325
50.59	1.4395	1.4365	1.4335
64.44	1.4406	1.4375	1.4344
79.70	1.4428	1.4395	1.4362
90.40	1.4447	1.4410	1.4373
100.00	1.4459	1.4415	1.4371

529. B = $C_{18}H_{36}O_2$, Stearic acid (101)

0.00	1.4339	1.4304	1.4269
10.46	1.4341	1.4307	1.4273
25.00	1.4345	1.4310	1.4275
40.00	1.4348	1.4313	1.4278
53.85	1.4353	1.4317	1.4281
70.00	1.4357	1.4320	1.4283
90.00	1.4365	1.4327	1.4289
100.00	1.4374	1.4335	1.4296

See also 342, 588 and Figs. 4, 5, 6.

$C_{17}H_{12}O_3$

Naphthyl salicylate (betol) (90)

$C_{17}H_{14}Br_2O_2$

Ethyl 2, 7-dibromofluorene-9-acetate; *see* 513

$C_{18}H_{18}$

Retene; *see* 514

$C_{18}H_{22}N_2$

Dibenzylpiperazine; *see* 343, 393

$C_{18}H_{34}O_2$

Oleic acid

530. B = $C_{18}H_{36}O_2$, Stearic acid (101)

% B	n_D^{60}	n_D^{70}	n_D^{80}
0.00	1.4459	1.4415	1.4371
10.00	1.4447	1.4399	1.4351
20.00	1.4441	1.4391	1.4341
30.58	1.4436	1.4386	1.4336
44.05	1.4425	1.4377	1.4329
60.00	1.4412	1.4365	1.4318
74.70	1.4398	1.4354	1.4310
86.53	1.4386	1.4344	1.4302
100.00	1.4374	1.4335	1.4296

See also 345, 528, 588 and Figs. 4, 5, 6.

$C_{18}H_{36}O_2$

Stearic acid; *see* 346, 529, 530, 588

$C_{19}H_{16}$

Triphenylmethane; *see* 302

$C_{19}H_{20}$

9-Isoamylanthracene (76)

$C_{19}H_{22}N_2O$

Cinchotoxine (Cinchonicine); *see* 347, 357

$C_{20}H_8Br_4O_5$

Eosin (143)

$C_{20}H_{28}O_2$

1, 4-Dihydroxynaphthalene diamyl ether (76)

$C_{20}H_{28}O_2$

1, 5-Dihydroxynaphthalene diamyl ether; *see* 515

$C_{26}H_{26}N_2O_2$

Benzoylcinchotoxine (benzoylcinchonicine); *see* 348, 358

$C_{27}H_{44}$

α-Cholesterylene; *see* 394

$C_{27}H_{46}$

Cholestene; *see* 395

$C_{27}H_{46}O$

Cholesterol; *see* 396

$C_{27}H_{48}$

Cholestane; *see* 397

$C_{29}H_{48}OS_2$

Methyl cholesterylxanthogenate; *see* 398

$C_{29}H_{50}OS_2$

Methyl dihydrocholesterylxanthogenate; *see* 399

$C_{51}H_{98}O_6$

Tripalmitin

531. B = $C_{57}H_{104}O_6$, Triolein (101)

% B	n_D^{60}	n_D^{70}	n_D^{80}
0.00	1.4428	1.4402	1.4376
10.00	1.4443	1.4417	1.4391
23.57	1.4462	1.4434	1.4406
34.35	1.4475	1.4447	1.4419
45.00	1.4487	1.4459	1.4431
52.47	1.4498	1.4468	1.4438
61.05	1.4512	1.4481	1.4450
67.58	1.4518	1.4488	1.4458
79.30	1.4533	1.4500	1.4467
79.65	1.4534	1.4502	1.4476
90.10	1.4549	1.4513	1.4477
100.00	1.4561	1.4523	1.4485

532. B = $C_{57}H_{110}O_6$, Tristearin (101)

0	1.4427	1.4402	1.4377
10	1.4430	1.4404	1.4378
20	1.4434	1.4407	1.4380
31.15	1.4442	1.4409	1.4376
40	1.4450	1.4410	1.4370
50	1.4455	1.4410	1.4365
60	1.4454	1.4410	1.4366
65.15	1.4453	1.4410	1.4367
75	1.4450	1.4411	1.4372
78.75	1.4447	1.4411	1.4375
90	1.4445	1.4412	1.4379
100	1.4441	1.4413	1.4385

$C_{57}H_{104}O_6$

Triolein

533. B = $C_{57}H_{110}O_6$, Tristearin (101)

% B	n_D^{60}	n_D^{70}	n_D^{80}
0.00	1.4561	1.4523	1.4485
14.29	1.4546	1.4506	1.4466

533.—(*Continued*)

% B	n_D^{60}	n_D^{70}	n_D^{80}
27.27	1.4534	1.4491	1.4448
38.46	1.4522	1.4480	1.4438
51.02	1.4506	1.4467	1.4428
68.15	1.4485	1.4448	1.4411
86.05	1.4464	1.4431	1.4398
100.00	1.4441	1.4413	1.4385

See also 531, 589 and Figs. 7, 8, 9.

$C_{57}H_{110}O_6$

Tristearin (stearin); *see* 532, 533, 589

Acetoacetic ester derivatives (60, 89)

Albumen (127)

Albumin

See Table 4.

Oil of Bergamot

534. B = Sandalwood oil (96)

% B	0.0	60.0	80.0
t		n_D^t	
19.7		1.4907	1.4996
29.6	1.4613	1.4863	1.4959
35.1	1.4588	1.4842	1.4932
41.1		1.4819	1.4905

Blood serum

See Table 4 and (46)

Castor oil (42)

Cinnamon, Oil of

See 526 (154)

Diketones (140, 142)

Dyestuffs, Commercial

(32)

Eosin derivatives

(143)

Gelatin

See 228.1

Glyoximes (23)

Nitroaniline derivatives

(59)

Paraffin oil (42)

Proteins

See Table 4

Sandalwood oil

See 527, 534

Turpentine, Oil of (62)

TABLE 2.—REFRACTIVITY AT ONE WAVE-LENGTH (*D*): TERNARY MIXTURES

For dispersion and refraction at other wave-lengths, *see* end of Table 5. For order of arrangement, *see* Vol. III, p. viii; for refractivity of corresponding binary mixtures, *see* same authority in Table 1. (Pulfrich) (Abbe-Zeiss) . . . indicate the type of refractometer used.

$\delta_d^t + 1000 = 1000d_4^t$, $\delta_n^t + 1333 = 1000n_D^t$, M_C = g-moles C per liter of mixture; % B = g B per 100 g of mixture; 1 Vol. B + 2 Vol. C = mixture of 1 volume of solution containing B to 2 volumes of solution containing C; Vol. % B, $t°$ = volume % of B at t°C; g B/l soln. = g B per liter of mixture.

I. Aqueous Mixtures, Standard Arrangement

H_2O

535. B = HIO_3; C = MoO_3 (113)

g B/l soln.	g C/l soln.	δ_n^{25}	δ_d^{25}
4.4867	0	0.11	0.93
0	12.0676	1.74	7.08
1 Vol. B + 2 Vol. C		1.14	4.93

536. B = HIO_3, M_B = 0.5; C = NaOH, M_C = 0.5; t = 21°C (28)

Vol. % B, 21°	n_D^t
0.0	1.3380
9.0	1.3382
16.7	1.3384
23.0	1.3385
33.3	1.3387
41.2	1.3389
45.4	1.3390
47.6	1.3391
50.0	1.3392
52.6	1.3395
55.5	1.3397
58.8	1.3401
62.5	1.3405
66.6	1.3409
71.5	1.3414
77.0	1.3421
83.3	1.3426
91.0	1.3435
100.0	1.3444

537. B = HIO_4, M_B = 0.5; C = NH_4OH, M_C = 0.5; t = 25°C (28)

0.0	1.3326
6.2	1.3331
11.7	1.3347
16.7	1.3357
21.0	1.3364
25.0	1.3371
28.6	1.3377
31.8	1.3381
34.8	1.3381
37.5	1.3379
40.0	1.3378
42.3	1.3376
44.4	1.3374

538. B = HIO_4, M_B = 0.5; C = NaOH, M_C = 0.5; t = 26°C (28)

Vol. % B, 21°	n_D^t
43.5	1.3376
45.4	1.3374
47.7	1.3372
50.0	1.3372
52.7	1.3376
55.6	1.3381
58.8	1.3386
62.5	1.3391
66.7	1.3396
71.4	1.3403
77.0	1.3413
83.4	1.3422
91.0	1.3433
100.0	1.3445

539. B = HIO_4, M_B = 0.967; C = KOH, M_C = 1.0; t = 25°C (28)

0.0	1.3427
4.7	1.3430
9.0	1.3433
13.0	1.3437
16.6	1.3440
20.0	1.3443
23.0	1.3445
25.8	1.3446
28.5	1.3446
31.0	1.3445
33.3	1.3445

540. B = H_2SeO_3, M_B = 1.0; C = NH_4OH, M_C = 1.0; t = 19°C (28)

16.2	1.3379
23.1	1.3395
28.6	1.3408
33.3	1.3421
37.5	1.3422
41.2	1.3422
44.5	1.3422
47.4	1.3423
50.0	1.3423

541. B = HNO_3; C = $Hg(NO_3)_2$ (Pulfrich) Anhydrous (94)

% C	n_D^{20}	d_4^{20}
0	1.3394	1.0253
5.3037	1.3451	1.0767
0	1.3423	1.0373
6.6201	1.3495	1.1014

H_2O.—(*Continued*)

542. B = $\mathbf{HNO_3}$; C = $\mathbf{Hg_2(NO_3)_2}$ (Pulfrich), Anhydrous (94)

% C	n_D^{20}	d_4^{20}
0	1.3385	1.0209
4.0118	1.3424	1.0563
7.4925	1.3465	1.0913
0	1.3394	1.0253
7.9896	1.3477	1.0991

543. B = $\mathbf{NH_4OH}$, M_B = 2; C = $\mathbf{H_3PO_3}$, M_C = 2; t = 19°C (28)

Vol. % C	n_D^t
15	1.3406
20	1.3426
25	1.3446
30	1.3464
33.3	1.3478
40	1.3468
45	1.3461
50	1.3454
65	1.3455

544. B = $\mathbf{NH_4OH}$, M_B = 2.0; C = $\mathbf{C_6H_8O_7}$, Citric acid, M_C = 2.0; t = 15°C (28)

0.0	1.3352
10.0	1.3438
15.0	1.3476
20.0	1.3520
25.0	1.3563
30.0	1.3578
40.0	1.3608
50.0	1.3640
60.0	1.3672
70.0	1.3704
80.0	1.3736
90.0	1.3768
100.0	1.3800

545. B = $\mathbf{(NH_4)_2SO_4}$; C = $\mathbf{Al_2(SO_4)_3}$ (113)

g B/l soln.	g C/l soln.	δ_n^{25}	δ_d^{25}
0	68.475	14.10	68.88
26.440	0	3.79	12.44
1 Vol. B + 1 Vol. C		8.94	40.94

546. B = $\mathbf{(NH_4)_2SO_4}$; C = $\mathbf{K_2SO_4}$ (113)

0	33.872	3.61	24.37
26.440	0	3.79	12.44
1 Vol. B + 1 Vol. C		3.70	18.40

547. B = $\mathbf{P_2O_5}$; C = $\mathbf{MoO_3}$ (113)

3.2267	0	0.41	0.79
0	12.0844	2.14	8.32
1 Vol. B + 2 Vol. C		1.56	5.73

548. B = $\mathbf{H_3PO_3}$, M_B = 2; C = **KOH**, M_C = 2; t = 17.5°C (28)

Vol. % B	n_D^t
0.0	1.3530
9.1	1.3515
16.7	1.3504
23.1	1.3493
28.6	1.3485
33.3	1.3476
37.5	1.3469
41.2	1.3464
44.5	1.3459
47.4	1.3454
50.0	1.3450
52.6	1.3450
55.5	1.3451
58.8	1.3452
62.5	1.3454
66.6	1.3457
71.4	1.3458
76.9	1.3462
83.3	1.3465
90.9	1.3472
100.0	1.3479

549. B = $\mathbf{H_3PO_4}$, M_B = 2; C = **KOH**, M_C = 2; t = 12 to 12.5°C (28)

Vol. % B	n_D^t	d_4^t
0.0	1.3538	1.0964
4.7	1.3534	
9.1	1.3530	
16.7	1.3525	1.0983
20.0	1.3522	
23.1	1.3520	
24.5	1.3518	1.0991
25.9	1.3515	
28.6	1.3509	1.0977
31.0	1.3505	
33.3	1.3500	1.0960
37.5	1.3493	1.0947
41.2	1.3488	1.0936
44.5	1.3484	
47.4	1.3482	1.0927
50.0	1.3480	
52.6	1.3480	1.0929
55.5	1.3481	
58.8	1.3482	1.0940
62.5	1.3483	
66.6	1.3484	1.0957
71.4	1.3486	
76.9	1.3489	1.0980
83.8	1.3493	
90.9	1.3499	1.1025
100.0	1.3507	1.1056

550. B = $\mathbf{H_4P_2O_7}$, M_B = 0.5; C = **KOH**, M_C = 1.0; t = 15°C (28)

550.—(*Continued*)

Vol. % B	n_D^t
0.0	1.3439
9.1	1.3431
16.2	1.3425
23.1	1.3420
28.6	1.3416
33.3	1.3412
37.5	1.3410
41.2	1.3408
44.5	1.3407
47.4	1.3406
50.0	1.3404
52.6	1.3405
55.5	1.3406
58.8	1.3407
62.5	1.3409
66.6	1.3411
71.4	1.3414
76.9	1.3418
83.8	1.3422
90.9	1.3429
100.0	1.3435

551. B = $\mathbf{As_2O_5}$; C = $\mathbf{MoO_3}$ (113)

g B/l soln.	g C/l soln.	δ_n^{25}	δ_d^{25}
12.7597	0	1.40	8.45
0	12.0844	2.14	8.32
1 Vol. B + 1 Vol. C		1.79	8.41

552. B = $\mathbf{C_6H_6}$, Benzene;* C = $\mathbf{CH_4O}$, Methyl alcohol (7)

* No numerical values of n; a triangular diagram too small for accurate reproduction; analyses of layers in heterogeneous portion; it is stated that at 25°C the area of the heterogeneous portion = 0.7658 of total area of the triangular diagram, in contrast with 0.6739 for the system C_2H_5OH-C_6H_6-H_2O; *v.* 557.

B = $\mathbf{C_6H_6}$, Benzene; C = $\mathbf{C_2H_6O}$, Ethyl alcohol, *v.* 557

553. B = $\mathbf{C_2H_2O_4}$, Oxalic acid; C = $\mathbf{MoO_3}$ (113)

3.1407	0	−0.11	−1.34
0	12.0676	1.74	7.08
1 Vol. B + 1 Vol. C		−0.18	2.89

554. B = $\mathbf{C_2H_4O_2}$, Acetic acid; C = $\mathbf{MoO_3}$ (113)

183.753	0	18.10	32.35
0	5.7626	0.51	1.86
2 Vol. B + 1 Vol. C		12.67	23.34

555. B = $\mathbf{C_2H_4O_3}$, Glycolic acid; C = $\mathbf{MoO_3}$ (113)

40.4302	0	3.32	10.06
0	4.8034_5	0.37	1.19
1 Vol. B + 2 Vol. C		1.44	4.23

556. B = $\mathbf{C_2H_6O}$, Ethyl alcohol, δ_n^{15} = 30.66; C = $\mathbf{C_4H_{10}O}$, Ethyl ether, δ_n^{15} = 22.43; for H_2O, δ_n^{15} = 0.39; (Zeiss) t = 15°C (125)

% C	0	5	10
% B		δ_n^{15}	
0	0.39	4.506	
5	3.670	8.240	
10	7.290	12.111	
15	11.184	15.841	
20	15.246	19.272	22.510
25	18.579	22.294	24.860
30	21.574	24.860	27.128
35	24.348	26.837	28.630
40	26.516	28.343	30.158
45	28.378	29.945	31.360
50	30.050	31.174	32.280
55	31.120	32.242	33.155
60	32.070	33.120	33.540
65	32.980	33.540	33.820
70	33.435	33.785	33.855
75	33.715	33.855	33.715
80	33.875	33.680	33.225
85	33.645	33.225	32.105
90	33.159	32.070	30.554
95	32.000	30.590	
100	30.66		

% C	15	20	25
% B		δ_n^{15}	
25	26.732		
30	28.558	29.800	30.695
35	30.050	31.115	31.820

556.—(*Continued*)

% C	15	20	25
% B		δ_n^{15}	
40	31.185	32.175	32.840
45	32.245	33.050	33.400
50	33.190	33.575	33.820
55	33.505	33.855	33.890
60	33.855	33.960	33.610
65	33.925	33.645	32.910
70	33.680	33.050	31.856
75	33.225	32.070	29.905
80	32.105	30.230	
85	30.302		

% C	30	35	40
% B		δ_n^{15}	
30	31.150	31.712	32.105
35	32.350	32.700	32.875
40	33.190	33.365	33.190
45	33.610	33.575	33.085
50	33.750	33.310	32.350
55	33.540	32.455	31.010
60	32.870	31.360	28.990
65	31.640	29.310	
70	29.765		

% C	45	50	55
% B		δ_n^{15}	
30	32.280	32.420	31.856
35	32.875	32.385	31.325
40	32.805	31.856	30.050
45	32.140	30.554	28.090
50	30.835	28.630	
55	28.954		

% C	60	65	70
% B		δ_n^{15}	
20			29.800
25	31.115	30.302	28.847
30	30.835	29.240	26.948
35	29.590	27.272	
40	27.632		

% C	75	80	90
% B		δ_n^{15}	
10			24.068
15		27.380	
20	28.055	25.436	
25	26.120		
% B = 5	% C = 95	$\delta_n^{15} = 23.132$	
% B = 0	% C = 100	$\delta_n^{15} = 22.43$	

557. B = $\mathbf{C_2H_6O}$, Ethyl alcohol;* C = $\mathbf{C_6H_6}$, Benzene, *D*, 25°C (Fery, direct reading) ([8]); *see* Fig. 1

% B	% C	δ_n^{25}	d_4^{25}
0.00	0.00	− 0.7	0.99707
0.00	100.00	+164.9	0.87363
5.85	93.66	145.0	
5.86	93.90	155.2	
5.89	94.11	155.0	
10.00	0.00	5.8	0.98043
10.00	89.93	148.5	0.86309
10.00	90.00	148.7	0.86299
10.09	88.93	147.7	
10.09	89.30	148.1	
10.9	89.91	148.8	
18.48	81.52	136.1	0.85503
20.00	0.00	13.0	0.96639
20.00	76.97	129.8	
20.00	77.69	130.7	0.85668
20.00	80.00	133.6	
21.42	77.16	129.8	
24.02	73.31	124.5	
27.06	68.80	117.8	
29.54	65.12	113.2	
30.00	0.00	18.4	0.95067
30.00	0.40	18.5	
30.00	0.50	18.6	
30.00	63.20	110.3	
30.00	63.81	111.0	0.85430
30.00	65.44	113.2	0.85161
30.00	67.28	114.9	0.84897
30.00	67.58	115.9	0.84818
30.00	70.00	118.8	0.84474
32.42	60.85	107.3	0.85287
35.26	56.64	101.5	
38.08	52.46	96.0	0.85238
40.00	0.00	23.5	0.93148
40.00	0.40	24.1	0.93063
40.00	1.23	25.1	
40.00	1.50	25.7	
40.00	48.61	90.7	0.85332
40.00	54.31	97.7	0.84490
40.00	59.72	104.3	0.83600
40.00	60.00	104.6	0.83574
40.68	48.61	90.9	
43.43	44.53	85.5	0.85199
45.96	40.78	80.5	
46.90	6.91	33.0	
47.13	5.46	32.4	
47.49	4.74	31.5	
49.85	1.22	28.0	0.90787
49.85	0.00	26.8	0.91019
49.83	35.04	72.8	
50.00	0.00	26.6	0.90985
49.86	2.64	30.6	
49.86	4.99	32.9	0.90068
50.00	5.87	33.8	0.89923
49.87	6.67	35.0	
49.87	7.43	36.2	
50.00	8.44	37.1	0.89460
49.88	9.03	38.5	
49.94	28.23	64.3	
49.94	29.30	65.7	
49.94	30.48	67.2	
50.00	30.80	67.3	0.87791
50.00	35.76	73.6	0.85000
50.00	39.85	78.9	0.84352
50.00	44.18	84.4	0.83613
50.00	50.00	90.9	0.82869
51.49	32.58	69.8	0.85189
60.00	0.00	28.7	0.88689
60.00	3.90	33.2	0.87958
60.00	7.05	37.3	0.87388
60.00	14.06	46.0	0.86180
60.00	19.16	52.1	0.85367
60.00	23.21	57.6	0.84701
60.00	28.60	64.5	0.83799

557.—(*Continued*)

% B	% C	δ_n^{25}	d_4^{25}
60.00	34.47	71.0	0.82797
60.00	40.00	77.3	0.81825
70.00	0.00	29.6	0.86340
70.00	7.46	38.7	0.85007
70.00	10.72	42.2	0.84421
70.00	14.68	46.8	0.83716
70.00	18.09	50.8	0.83165
70.00	22.45	55.5	0.82388
70.00	24.31	57.4	0.82014
70.00	25.64	58.8	0.81810
70.00	30.00	63.2	0.80953
73.46	0.00	29.8	0.85506
79.98	0.00	29.9	0.83911
79.98	3.58	33.7	0.83267
79.98	9.23	40.3	0.82271
79.99	13.75	45.0	0.81418
79.99	15.89	47.2	0.81021
79.99	20.01	50.9	0.80095
89.97	0.00	29.0	0.81369
89.94	2.42	31.4	0.80922
89.92	4.99	33.9	0.80418
89.90	7.53	36.6	0.79897
89.87	10.13	38.8	0.79343
100.00	0.00	26.2	0.78506

* At 25°C the area of the heterogeneous portion = 0.6739 of total area of triangular diagram.

558. B = C_2H_6O, Ethyl alcohol; C = $Ca(NO_3)_2$; concentration of C_2H_6O in B ≡ % B; of C in B ≡ M_C; t = 18°C (93)

M_C	0.0	0.2	0.5
% B		δ_n	
0.0	0.1	6.8	11.4
18.5	12.1	15.8	21.5
41.2	25.9	30.0	35.6
60.8	30.3	34.3	39.4
74.0	32.0	36.3	42.0
91.9	30.5	34.5	40.8
100.0	26.9	32.1	39.0
M_C	1.0	1.5	2.0
% B		δ_n	
0.0	22.8	33.2	43.5
18.5	30.9	40.4	49.3
41.2	44.0	52.7	61.0
60.8	47.3	55.6	63.9
74.0	50.6	59.4	68.0
91.9	50.4	59.6	73.0
100.0	49.3	59.6	77.8

559. B = $C_3H_6O_2$, Propionic acid; C = MoO_3, t = 25°C (113)

g B/l soln.	g C/l soln.	δ_n	δ_d
221.397	0	17.92	13.62
0	11.5253	1.57	6.60
2 Vol. B + 1 Vol. C		12.76	12.11

560. B = $C_3H_6O_3$, Lactic acid; C = MoO_3; t = 25°C (113)

g B/l soln.	g C/l soln.	δ_n	δ_d
93.8597	0	10.26	21.79
0	11.5253	1.57	6.60
1 Vol. B + 2 Vol. C		3.93	11.87

561. B = $C_4H_6O_4$, Succinic acid; C = MoO_3; t = 25°C (113)

g B/l soln.	g C/l soln.	δ_n	δ_d
45.8425	0	4.30	10.77
0	1.3131	−0.28	−1.86
1 Vol. B + 2 Vol. C		1.26	2.37

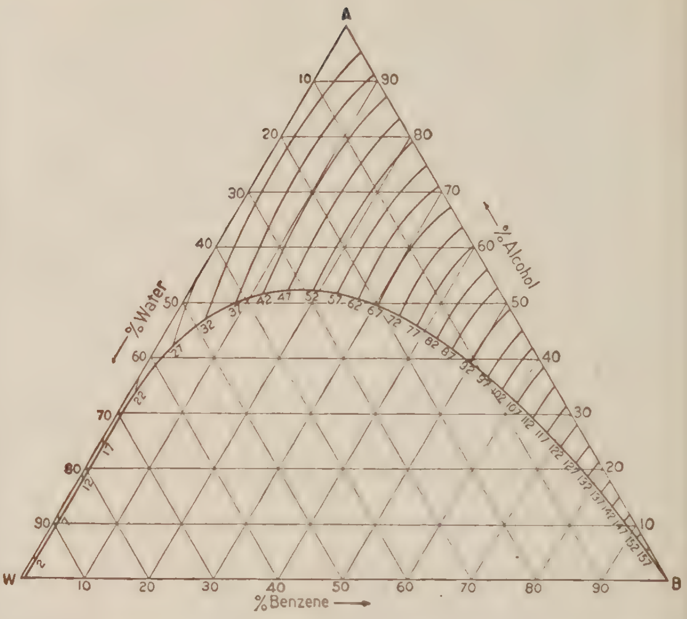

FIG. 1.—Refractivity of system 557; Water (H_2O), Ethyl alcohol (C_2H_6O), and Benzene (C_6H_6).

Coordinates are Wt. %; on curve are values of δ_n, $1000n_D^{25} = 1333 + \delta_n$. Below the curve the system is heterogeneous; *see* 557, Table 2.

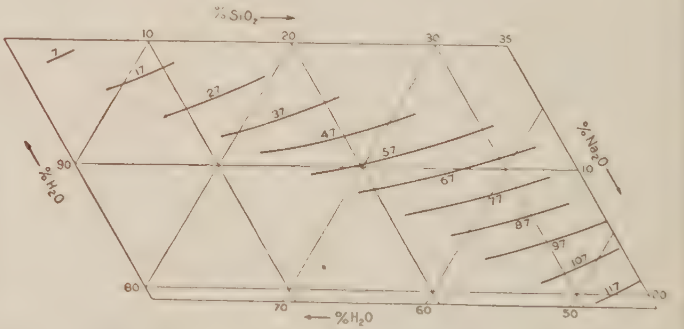

FIG. 2.—Refractivity of system 570; $H_2O + SiO_2 + Na_2O$ (145).

Coordinates are Wt. %; on curves are values of δ_n, $1000n = 1333 + \delta_n \pm 1$. Neither t nor λ recorded, but λ is obviously *D*. *See* 570, Table 2.

562. B = $C_4H_6O_5$, Malic acid; C = MoO_3; t = 25°C (113)

g B/l soln.	g C/l soln.	δ_n	δ_d
168.079	0	18.56	57.82
0	11.8732	1.72	7.21
1 Vol. B + 2 Vol. C		7.38	24.42

563. B = $C_4H_6O_6$, Tartaric acid; C = MoO_3; t = 25°C (113)

g B/l soln.	g C/l soln.	δ_n	δ_d
73.6565	0	8.45	20.69
0	22.3675	3.49	15.54
1 Vol. B + 1 Vol. C		6.30	22.80

564. B = $C_4H_6O_6$, Tartaric acid; C = $(NH_4)_6Mo_7O_{24}$; t = 25°C (113)

g B/l soln.	g C/l soln.	δ_n	δ_d
200.00	0	23.26	84.40
0	200.00	32.19	135.60
2 Vol. B + 1 Vol. C		29.29	109.27

565. B = $C_6H_8O_7$, Citric acid; C = MoO_3; t = 25°C (113)

g B/l soln.	g C/l soln.	δ_n	δ_d
89.8126	0	9.53	30.39
0	11.5253	1.57	6.60
1 Vol. B + 2 Vol. C		4.37	14.72

566. B = $C_6H_8O_7$, Citric acid, M_B = 2.0; C = **NaOH,** M_C = 2.0; t = 15°C (28)

Vol. % B	n_D^t	Vol. % B	n_D^t
0.0	1.3535	50.0	1.3625
10.0	1.3539	60.0	1.3659
15.0	1.3541	70.0	1.3694
20.0	1.3543	80.0	1.3729
25.0	1.3545	90.0	1.3763
30.0	1.3561	100.0	1.3800
40.0	1.3592		

567. B = $C_7H_{12}O_6$, Quinic acid; C = **MoO_3**; t = 25°C (113)

g B/l soln.	g C/l soln.	δ_n	δ_d
53.8721	0	7.27	17.22
0	5.49045	0.47	1.46
1 Vol. B + 2 Vol. C		2.92	6.82

568. B = $C_8H_8O_2$, Phenylacetic acid; C = **MoO_3**; t = 25°C (113)

5.8743	0	+0.57	−2.00
0	1.0030	−0.33	−2.09
2 Vol. B + 1 Vol. C		+0.27	−2.02

569. B = $C_8H_8O_3$, Phenylglycolic acid; C = **MoO_3**; t = 25°C (113)

84.7143	0	14.83	17.04
0	9.4047	1.26	4.41
1 Vol. B + 2 Vol. C		6.14	9.34

570. B = **SiO_2**; C = **Na_2O**; *see* Fig. 2; commercial sodium silicate* (145)

% B	% C	n	d
$x(Na_2O + 1.69SiO_2)$			
1.05	0.64	1.3358	1.0161
3.13	1.90	1.3425	1.0584
6.65	4.04	1.3550	1.1069
9.90	6.02	1.3651	1.1637
13.34	8.10	1.3770	
16.70	10.14	1.3886	1.2970
19.82	12.04	1.4010	1.3705
21.40	13.00	1.4077	1.4037
22.94	13.93	1.4127	1.4414
23.81	14.46	1.4157	1.4646
24.70	15.00	1.4188	
25.69	15.60	1.4235	
26.51	16.10	1.4264	
28.23	17.14	1.4337	
29.69	18.03	1.4390	
31.58	19.18	1.4473	
32.58	19.78	1.4473†	
$x(Na_2O + 2.06SiO_2)$			
2.96	1.48	1.3399	
5.98	2.99	1.3484	1.0829
9.00	4.50	1.3570	1.1328
12.12	6.06	1.3651	1.1789
15.32	7.66	1.3740	
16.86	8.43	1.3787	1.2664
18.76	9.38	1.3850	1.3028
21.06	10.53	1.3916	1.3426
22.24	11.12	1.3972	1.3653
23.10	11.55	1.3984	1.3849
24.02	12.01	1.4016	1.4023
24.86	12.43	1.4043	1.4188
25.78	12.89	1.4090	1.4428
26.60	13.30	1.4122	
29.60	14.80	1.4222	
$x(Na_2O + 2.40SiO_2)$			
1.21	0.52	1.3359	1.0147
2.41	1.03	1.3388	1.0313
7.06	3.02	1.3495	1.0935
11.66	4.99	1.3610	1.1600
$x(Na_2O + 2.44SiO_2)$			
16.68	7.04	1.3734	
19.64	8.29	1.3823	1.2866
21.92	9.25	1.3883	1.3266
24.17	10.20	1.3948	1.3783
25.64	10.82	1.4009	1.3969
27.00	11.40	1.4059	1.4230
28.39	11.98	1.4100	1.4529
29.43	12.42	1.4142	
30.64	12.93	1.4176	
31.65	13.36	1.4219	
32.89	13.88	1.4247	
$x(Na_2O + 3.36SiO_2)$			
1.80	0.55	1.3368	1.0183
3.36	1.03	1.3403	
6.72	2.06	1.3470	1.0733
9.89	3.03	1.3529	1.1137
13.15	4.03	1.3609	1.1499
16.58	5.08	1.3671	1.1934
19.49	5.97	1.3733	1.2404
21.18	6.49	1.3777	1.2653
22.46	6.88	1.3809	1.2839
24.38	7.47	1.3860	1.3170
26.24	8.04	1.3905	1.3476
27.74	8.50	1.3944	1.3692
29.76	9.12	1.3997	1.4078
$x(Na_2O + 3.90SiO_2)$			
1.86	0.49	1.3367	1.0190
3.75	0.99	1.3400	1.0394
5.69	1.50	1.3430	1.0584
7.55	1.99	1.3466	1.0781
9.41	2.48	1.3501	1.0985
11.34	2.99	1.3538	1.1206
13.31	3.51	1.3570	1.1435
14.98	3.95	1.3614	1.1656
17.7‡	4.64	1.3666	
20.82	5.49	1.3718	
21.96	5.79	1.3735	
22.99	6.06	1.3774	
23.89	6.30	1.3793	
24.28	6.40	1.3800	
24.54	6.47	1.3807	
25.11	6.62	1.3814	1.3028
25.75	6.79	1.3840	1.3063
26.21	6.91	1.3844	
26.59	7.01	1.3855	

* Impurities, computed as metallic oxides, = 1 % of ($Na_2O + ySiO_2$) content. Neither t nor λ is recorded, but λ is obviously D; accuracy in d and n is probably not greater than ±0.001.

† 1.4493(?). ‡ 17.6(?)

571. B = **HgI_2**; C = **BaI_2**, Rohrbach's solution* (87); 100 g BaI_2 + 130 g HgI_2 + xH_2O

d_4^{20}	n_D^{20}	d_4^{20}	n_D^{20}
2.067	1.5148	3.046	1.6944
2.163	1.5320	3.180	1.7195
2.367	1.5685	3.246	1.7312
2.648	1.6205	3.396	1.7590
2.649†	1.6207†	3.449	1.7656
2.748	1.6391	±0.0015	±0.00015
2.980	1.6823		

$(\delta d/\delta t)_{20} = +0.0005$. If $2.00 < d^{20} < 2.25$, $d^{20} = 5.70n_D^{20} - 6.567$; $2.25 < d^{20} < 3.40$, $d^{20} = 5.39n_D^{20} - 6.0865$; $3.40 < d^{20} < 3.50$, $d^{20} = 5.52n_D^{20} - 6.313$.

* For determining density of minerals; 100 g BaI_2, 130 g HgI_2, and 20 cm^3 H_2O are rapidly mixed and heated to boiling point on an oil-bath, then diluted as desired.

† For quartz (SiO_2), $d_4^{20} = 2.6495$, $n_D^{20} = 1.6208$.

572. B = **$HgCl_2$**, $N = 0.2$; C = **KCl**, $N = 0.2$ (148)

Vol. % B, 18°	Vol. % C, 18°	n_D^{18}
0	1	1.33513
1	0	1.3381
1	1	1.3367
1	2	1.3362
2	1	1.3372

573. B = **$HgCl_2$**; C = **KI** (113)

g B/l soln.	g C/l soln.	δ_n^{25}	δ_d^{25}
54.18	0	4.12	41.66
0	33.20	3.76	20.93
1 Vol. B + 5 Vol. C		4.33	24.69

574. B = **$HgCl_2$**; C = **KCN** (113)

54.18	0	4.12	41.66
0	13.038	0.86	3.50
1 Vol. B + 1 Vol. C		2.52	22.53
54.18	0	4.11	41.53
0	13.038	0.86	3.46
1 Vol. B + 4 Vol. C		1.39	40.77

575. B = **$AgNO_3$**; C = **$LiNO_3$** (113)

169.97	0	16.76	136.15
0	69.07	5.00	23.38
1 Vol. B + 1 Vol. C		10.89	79.72

576. B = **$AgNO_3$**; C = **KCN** (113)

169.97	0	16.76	136.15
0	65.19	7.39	31.53
1 Vol. B + 3 Vol. C		9.20	54.64

577. B = **$MnSO_4$**; C = **$Mn(NO_3)_2$** (17)

g B/kg A	g C/kg A	n_D^{20}	α
7.5	6.3	1.3371	1.07

578. B = **$MnSO_4$**; C = **$Fe_2(SO_4)_3$** (17)

7.5	10.0	1.3391	1.20
7.5	20.1	1.3400	1.20
3.75	20.1	1.3413	1.20

579. B = **$FeCl_3$**; C = **$NiCl_2$** (17)

8.3	2.35	1.3419	1.00
8.3	6.5	1.3410	1.00
4.15	6.5	1.3401	1.13

580. B = **$Fe_2(SO_4)_3$**; C = **$Fe(NO_3)_3$** (17)

20.1	12.0	1.3427	1.20

580.1. B = **$Fe(NO_3)_3$**; C = **$Co(NO_3)_2$** (17)

g B/kg A	g C/kg A	n_D^{20}	α
12.0	4.5	1.3415	1.07
12.0	9.0	1.3408	1.13
6.0	9.0	1.3401	1.13

581. B = **$CoCl_2$**; C = **$CoSO_4$** (17)

6.5	7.6	1.3381	1.07

582. B = **CrO_3**; C = **MoO_3** (113)

g B/l soln., 25°	g C/l soln., 25°	δ_n^{25}	δ_d^{25}
3.59075	0	0.82	0.82
0	12.0844	2.14	8.32
2 Vol. B + 1 Vol. C		1.27	3.37

583. B = **$Al_2(SO_4)_3$**; C = **K_2SO_4** (113)

68.475	0	14.10	68.88
0	34.872	3.61	24.37
1 Vol. B + 1 Vol. C		8.82	46.57

584. B = **NaCl**; C = **KCl** (113)

58.5	0	9.23	37.04
0	74.6	9.08	42.63
1 Vol. B + 1 Vol. C		9.15	39.84

(138)	B	C	% C = 20 − % B	
% B or C	δ_n^{25}	δ_n^{25}	% B	δ_n^{25}
5	8.72	6.31	0	26.92
10	17.21	13.43	4.446	28.90
15	25.93	20.35	9.35	30.72
20	35.29	26.92	12.36	31.99
			20.00	35.29

585. B = **KI**; C = **KCN** (113)

g B/l soln., 25°	g C/l soln., 25°	δ_n^{25}	δ_d^{25}
33.00	0	3.76	20.93
0	13.036	0.86	3.50
1 Vol. B + 1 Vol. C		2.31	12.25

II. Non-Aqueous Mixtures; ℭ-Table, the ℭ-Arrangement

CCl_4

Carbon tetrachloride

586. B = **$C_2H_4Br_2$**, Ethylene bromide; C = **C_7H_8**, Toluene (129) (Pulfrich)*; $\delta = (n_D^{25} - 1.460) \times 1000$; *see also* Fig. 3

% A	δ	% A	δ
% B/% C = $1/9$		% B/% C = $3/7$	
0.00	34.3	0.00	37.7
9.64	32.4	10.05	35.1
19.79	30.2	20.05	32.7
29.93	27.8	30.57	29.6
39.97	24.9	39.93	26.5
49.97	22.1	50.37	22.7
59.99	18.4	59.84	19.1
69.91	14.3	69.90	14.8
79.93	9.6	79.99	9.5
90.14	4.0	89.51	3.7
% B/% C = $2/8$		% B/% C = $4/6$	
0.00	36.0	0.00	40.0
10.65	33.5	9.70	37.2
20.09	31.2	19.91	34.3
29.84	28.7	29.89	31.2
40.27	25.5	40.06	27.2
50.41	22.3	49.95	23.5
60.42	18.5	59.99	19.5
70.24	14.2	70.03	14.8
79.93	9.6	79.90	9.6
90.06	3.9	89.60	3.7

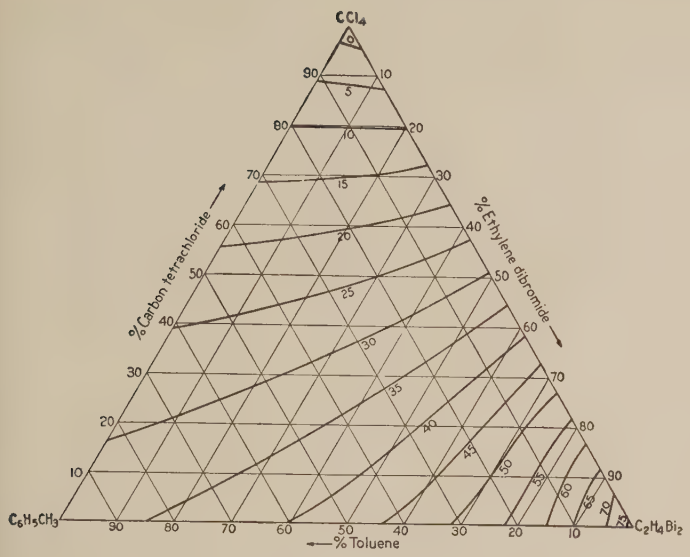

FIG. 3.—Refractivity of system 586; Carbon tetrachloride (CCl_4), Ethylene bromide ($C_2H_4Br_2$), Toluene (C_7H_8) (129).

Coordinates are Wt. %; on curves are values of δ, $1000n_D^{25} = 1640 + \delta$; *see* 586, Table 2.

586.—(*Continued*)

% A	δ	% A	δ
% B/% C = 5/5		% B/% C = 7/3	
0.00	42.7	50.05	25.6
9.87	39.7	60.16	20.7
20.34	35.9	69.95	15.4
29.82	32.8	79.88	9.5
39.87	28.5	89.52	3.6
50.06	24.2	% B/% C = 8/2	
59.90	19.6	0.00	57.0
69.93	15.0	9.88	51.3
79.95	9.5	20.03	45.2
90.15	3.7	30.47	39.4
% B/% C = 6/4		40.14	33.5
0.00	46.5	49.93	27.6
9.80	42.7	59.85	21.4
19.91	38.6	69.92	15.5
29.85	34.5	80.11	9.3
40.06	29.9	89.83	3.5
49.94	25.3	% B/% C = 9/1	
59.87	20.3	0.00	65.0
69.93	15.1	10.21	57.7
79.91	9.6	20.21	50.0
90.06	3.5	29.96	43.0
% B/% C = 7/3		39.91	36.1
0.00	51.0	50.02	29.0
10.11	46.3	60.15	22.4
19.76	41.5	69.99	15.9
29.71	36.5	80.17	9.4
39.99	31.5	89.95	3.5

586.—(*Continued*)

% C	0	10	20	30	40	50	60	70	80	90
% A/% B	δ*									
10/0	−2.5	+4.2	9.8	14.4	18.4	21.7	24.7	27.2	29.3	31.1
9/1	+3.4	9.1	13.7	17.5	20.6	23.4	25.9	28.2	29.9	31.5
8/2	9.6	14.2	17.6	20.7	23.2	25.6	27.4	28.9	30.5	31.7
7/3	16.3	19.3	22.0	24.0	25.8	27.5	28.9	30.2	31.3	32.0
6/4	23.4	24.9	26.2	27.5	28.5	29.5	30.3	31.1	31.7	32.3
5/5	30.6	31.1	31.1	31.3	31.6	31.7	31.9	32.2	32.4	32.7
4/6	38.8	37.1	35.7	34.9	34.4	33.9	33.5	33.2	33.1	33.0
3/7	47.3	43.5	40.7	38.6	37.1	35.9	35.1	34.4	33.8	33.3
2/8	56.6	50.6	45.9	42.6	40.1	38.2	36.7	35.5	34.7	33.6
1/9	66.7	57.8	51.4	46.8	43.2	40.4	38.4	36.5	35.2	34.1
0/10	76.3	65.0	57.0	51.0	46.5	42.8	40.0	37.7	36.0	34.3

* Data computed by formula $n^2 = (1.62197)^2 - \sin^2 e$, where e is angle of deviation.

$C_7H_5N_3O_6$

2, 4, 6-Trinitrotoluene

587. B = $C_7H_6N_2O_4$, 2, 4-Dinitrotoluene; C = $C_7H_7NO_2$, *p*-Nitrotoluene (11); (Abbe) t = 38 to 39°C; presumably *D*-line; approximately eutectic composition (melts *ca.* 17°C); $100n = 1.580(\%\ A) + 1.572(\%\ B) + 1.542(\%\ C) \pm 0.001$.

$C_{16}H_{32}O_2$

Palmitic acid

588. B = $C_{18}H_{34}O_2$, Oleic acid; C = $C_{18}H_{36}O_2$, Stearic acid (101); % A = % C = (100 − % B)/2; $\delta^t = 100(n_D^t - 1.42)$; *see* Figs. 4, 5, 6.

% A; % C	% B	δ^{60}	δ^{70}	δ^{80}
50.00	0.00	1.52	1.16	0.80
44.30	11.40	1.65	1.29	0.93
38.30	23.40	1.77	1.40	1.03
32.10	35.80	1.87	1.51	1.15
25.55	48.90	2.02	1.65	1.28
20.60	58.80	2.11	1.74	1.37
15.00	70.00	2.25	1.85	1.47
5.00	90.00	2.46	2.05	1.64
0.00	100.00	2.59	2.15	1.71

$C_{51}H_{98}O_6$

Tripalmitin

589. B = $C_{57}H_{104}O_6$, Triolein; C = $C_{57}H_{110}O_6$, Tristearin (101); % A = % C = (100 − % B)/2; $\delta^t = 100(n_D^t - 1.42)$; *see* Figs. 7, 8, 9.

% A; % C	% B	δ^{60}	δ^{70}	δ^{80}
50.00	0.00	2.45	2.10	1.65
44.79	10.42	2.62	2.22	1.82
39.09	21.82	2.72	2.36	2.00
34.32	31.36	2.80	2.50	2.20
29.46	41.08	2.93	2.61	2.29
24.32	51.36	3.05	2.73	2.41
18.05	63.90	3.19	2.88	2.57
9.95	80.10	3.39	3.07	2.75
4.36	91.28	3.51	3.16	2.81
0.00	100.00	3.61	3.23	2.85

% A	% B	% C	δ^{70}
71.06	5.25	23.69	2.11
23.15	7.40	69.45	2.20
66.56	11.25	22.19	2.21
21.16	15.36	63.48	2.29
57.19	23.75	19.06	2.36
17.46	30.16	52.38	2.49
41.93	44.10	13.97	2.63
12.57	49.72	37.71	2.72

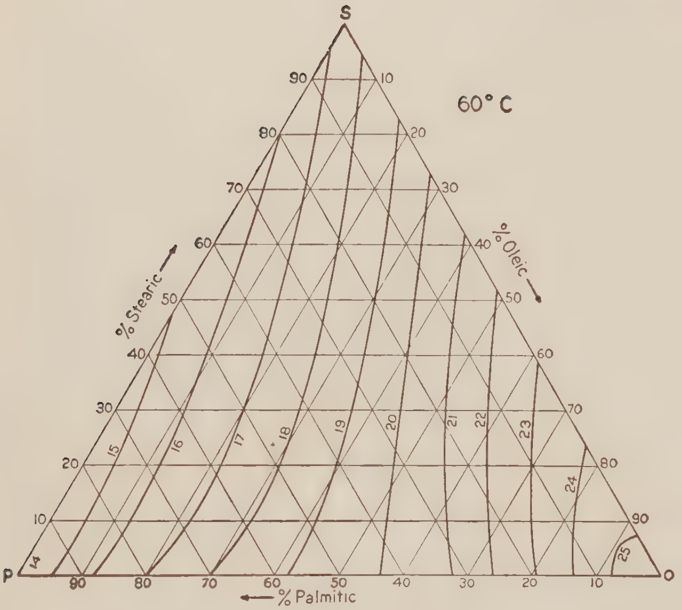

Fig. 4.

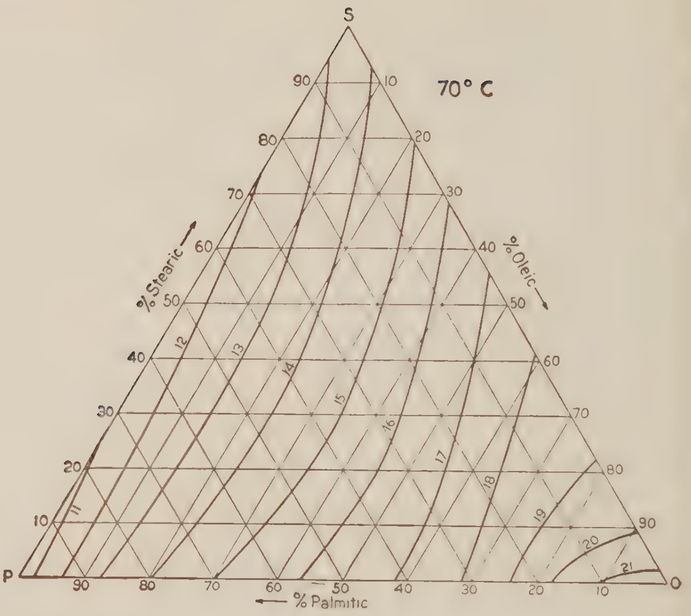

Fig. 5.

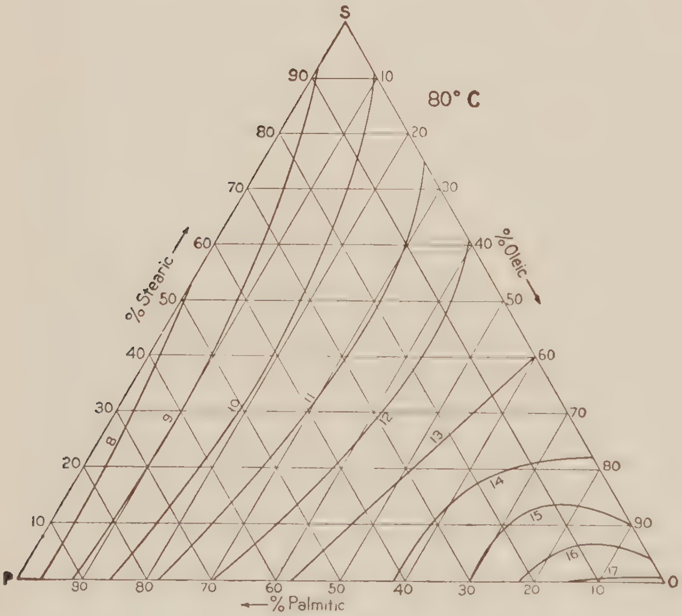

Fig. 6.

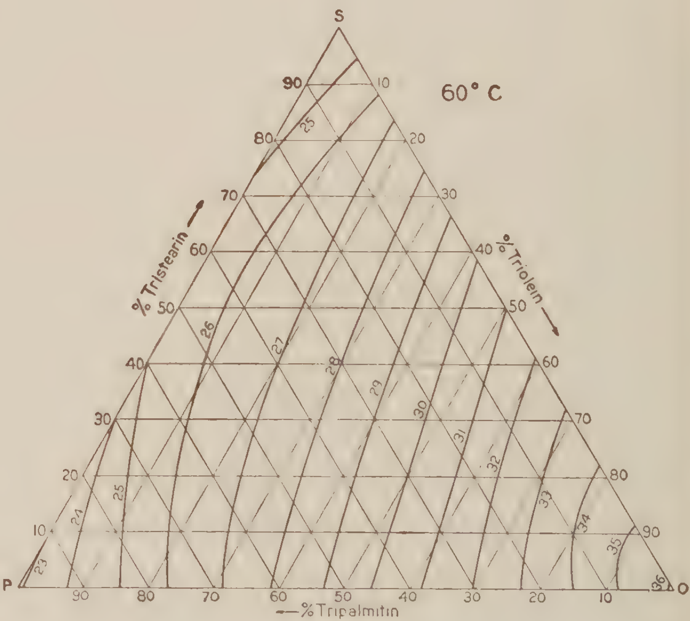

Fig. 7.

Figs. 4, 5, 6.—Refractivity of system 588; Palmitic ($C_{16}H_{32}O_2$), Oleic ($C_{18}H_{34}O_2$), and Stearic ($C_{18}H_{36}O_2$) acids (101). Coordinates are Wt. %; on curves are values of δ, $1000n_D^t = 1420 + \delta$; three temperatures, 60, 70, and 80°C; *see* 588, Table 2.

TABLE 3.—REFRACTIVITY AT ONE WAVE-LENGTH (*D*): QUATERNARY AQUEOUS SOLUTIONS (17)

Component A = H_2O; unit of concentration (C) = 1 g of B(C, D) per 1000 g of A

	B	C	D	C_B	C_C	C_D	n_D^{20}	α_{15}^{30}
590	$MnCl_2$	$MnSO_4$	$Mn(NO_3)_2$	4.2	5.0	6.0	1.3375	1.20
591	$FeCl_3$	$Fe_2(SO_4)_3$	$Fe(NO_3)_3$	5.5	13.4	8.0	1.3432	1.20
592	$CoCl_2$	$CoSO_4$	$Co(NO_3)_2$	4.4	5.1	6.0	1.3382	1.13
593	$NiCl_2$	$NiSO_4$	$Ni(NO_3)_2$	4.4	5.1	6.1	1.3380	1.13
594	$CrCl_3$	$Cr_2(SO_4)_3$	$Cr(NO_3)_3$	1.1	2.7	1.6	1.3366	1.07

TABLE 4.—REFRACTIVITY OF SOLUTIONS OF PROTEINS: VARIOUS SOLVENTS

$n_D^t = (n_D^t)_0 + k(10)^{-6}$ (g A/l soln.); $(n_D^t)_0$ = value for solvent; $1000(n_D^t)_0 = 1333 + \delta_0$; $0.4S$ = 0.4 saturated; for symbols, *v.* p. 64

t	Solvent				k	Lit.
	B	C	Conc. of C	δ_0		
A = Albumins from ox-blood serum						
24	H_2O	$(NH_4)_2SO_4$	0 to $0.4S$		177 ± 8	(119)
A = Ovalbumen						
22.5	H_2O	$(NH_4)_2SO_4$	1 %	1.49	177 ± 6	(55)
22.5	H_2O	NaOH	$N = 0.1$	0.98	177 ± 6	(55)
23	H_2O	NaOH	N = 0.05 to 0.005		177 ± 6	(55)

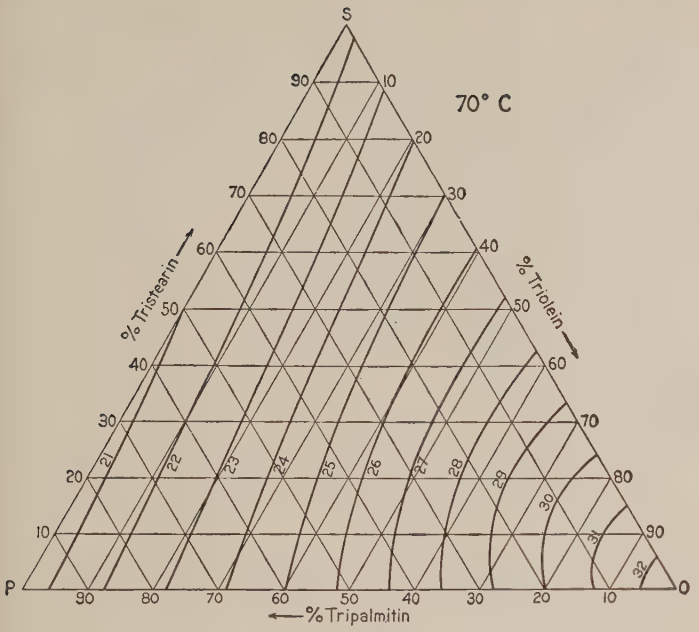

FIG. 8.

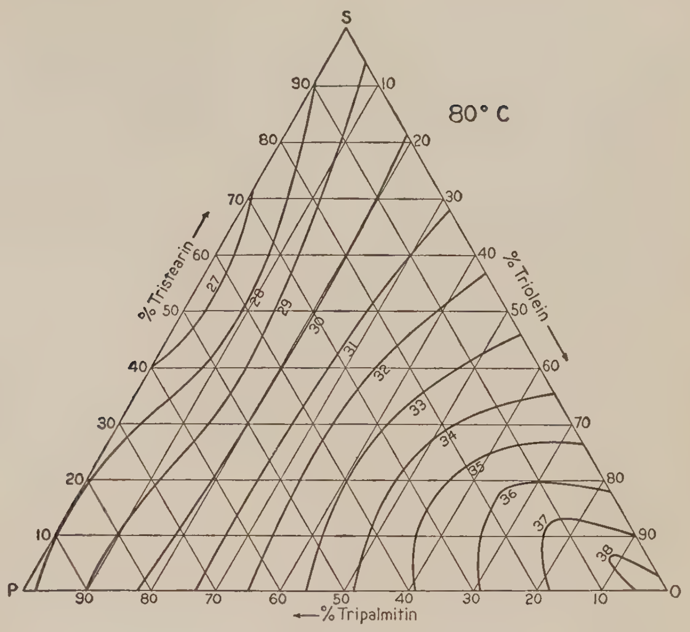

FIG. 9.

FIGS. 7, 8, 9.—Refractivity of system 589; Tripalmitin ($C_{51}H_{98}O_6$), Triolein ($C_{57}H_{104}O_6$), and Tristearin ($C_{57}H_{110}O_6$) (101). Coordinates are Wt. %; on curves are values of δ, $1000n_D^t = 1420 + \delta$; three temperatures, 60, 70, and 80°C; *see* 589, Table 2.

TABLE 4.—(*Continued*)

t	Solvent				k	Lit.
	B	C	Conc. of C	δ_0		
A = Casein						
20 to 40	H_2O	Ac., Al.*	†		152	(114)
25	H_2O	KOH	$N = 0.025$	− 1.30	149 ± 4	(118)
25	25 % C_2H_5OH‡	KOH	$N = 0.025$	+12.27	157 ± 5	(118)
25	50 % C_2H_5OH‡	KOH	$N = 0.025$	+23.50	149 ± 5	(118)
25	75 % C_2H_5OH‡	KOH	$N = 0.025$	29.26	125 ± 6	(118)
A = Edestin						
16 to 26	H_2O	Ac., Al., S.*	†		174 ± 6	(126)
A = Gliadin from wheat						
20	H_2O	KOH	$N = 0.1$	2.37	167 ± 6	(122)
25	H_2O	$C_2H_4O_2$‡	$N = 0.1$	1.26	161 ± 6	(122)
25	H_2O	C_2H_5OH‡	60 Vol. %	28.90	143 ± 6	(122)
25	H_2O	C_2H_5OH‡	70 Vol. %	31.50	152 ± 6	(122)
25	H_2O	C_3H_6O‡	25 Vol. %	15.21	168 ± 6	(122)
25	H_2O	C_3H_6O‡	50 Vol. %	27.82	147 ± 6	(122)
25	H_2O	C_3H_7OH‡	60 Vol. %	38.70	152 ± 6	(122)
25	H_2O	C_6H_6O‡	75 %	163.49	−38 ± 6	(122)
A = Globin from ox-blood						
18	H_2O	Ac., Al.*	$N = 0.1$		169 ± 5	(121)
A = Globin caseinate						
16	H_2O	KOH	$N = 0.1$	2.52	162 ± 5	(121)
A = Hemoglobin from horse						
19.5§	H_2O	NH_3	$N = 0.1$	1.1	183 ± 1	(69)
A = Serum globulin from ox						
23	H_2O	Ac., Al.*	‖		229	(117)
23	25 % C_2H_5OH‡	KOH	$N = 0.025$	12.78	202	(117)
23	50 % C_2H_5OH‡	KOH	$N = 0.025$	24.29	119	(117)
23	25 % C_3H_6O‡	KOH	$N = 0.025$	13.69	227	(117)
19	50 % C_3H_6O‡	KOH	$N = 0.025$	26.84	146	(117)
A = Ovomucoid						
18	H_2O		0	0.3	160	(115)
A = Ovovitellin						
18	H_2O	Al*	‖		130	(115)
A = Paranuclein						
22	H_2O	Al.*	‖		140	(116)
A = Protein: Total from ox-blood serum						
20	H_2O	KOH	$N = 0.01$		195 ± 2	(119)
A = Serum of ox-blood						
20	H_2O		0		195 ± 2	(119)
A = Salamine sulfate¶						
22	H_2O		0	1.10	174 ± 7	(3)
A = Salamine chloride¶						
18	H_2O		0	0.56	172 ± 16	(3)

* Ac., Al., S. = acids, alkalies, salts. † Various concentrations.

‡ $C_2H_4O_2$ = acetic acid; C_2H_5OH = ethyl alcohol; C_3H_6O = acetone; C_3H_7OH = *n*-propyl alcohol; C_6H_6O = phenol.

§ Same value for t = 19 to 21°C. ‖ Dilute. ¶ From prolamine from Pacific salmon.

TABLE 5.—SPECTRAL DISPERSION OF MIXTURES

For index of refraction at one wave-length, *see* Table 1 or 2; for formula index of substances, *see* Table 1; for order of arrangement, *see* Vol. III, p. viii. Each mixture has the same index number as in Table 1 or 2.

The tabular values $\binom{\lambda_1}{\lambda_2}$ represent differences in n; $n_{\lambda_2} = n_{\lambda_1} + \binom{\lambda_1}{\lambda_2} \times 10^{-5}$; the average dispersion between λ_1 and λ_2 is $\frac{n_{\lambda_2} - n_{\lambda_1}}{\lambda_1 - \lambda_2} = \binom{\lambda_1}{\lambda_2} \times \frac{10^{-5}}{(\lambda_1 - \lambda_2)}$ per unit of λ. The symbol expressing the concentration always refers to constituent B unless another is indicated.

By combining the differences given in this table with the value of n(for C, D, 5876, F, or 3256) for the same author, as given in Table 1 or 2, his values of n for other values of λ are obtained. Unit of λ = 1 A = 10^{-8} cm. t = centigrade temperature, °C.

I. Two-Component Aqueous Mixtures; Standard Arrangement

Only authorities (38, 65, 85, 86) have recorded the refraction and the dispersion of the H_2O used in making the solution, as follows:

(38) $t = 15°C$, $n_D^t = 1.33345$, $\binom{6708}{5893} = 219$, $\binom{5893}{5351} = 186$;

(65) $t = 18°C$, $n_{3256}^t = 1.35326$, $\binom{4679}{3256} = 1491$, $\binom{3612}{3256} = 568$,

$\binom{3405}{3256} = 262$, $\binom{3256}{2981} = 624$, $\binom{3256}{2749} = 1332$, $\binom{3256}{2574} = 2040$, $\binom{3256}{2314} = 3576$; (85) $t = 70°C$, $n_D^t = 1.32522$, $\binom{C}{D} = 175$, $\binom{D}{F} = 431$; (86) $t = 18°C$, $n_D^t = 1.33322$, $\binom{C}{D} = 183$, $\binom{D}{F} = 415$, $\binom{F}{G'} = 323$.

7. B = $\mathbf{H_2SO_4}$, 95 to 96% H_2SO_4; electrically heated SiO_2 prism, indices corrected to air at 20°C and 1 atm (15)

t	$\binom{5893}{5780}$	$\binom{5893}{4358}$
28.4*	5#	80#
49.1	3#	79#
85.8	4#	75#
113.8	4#	75#
173.9	6#	76#
206.8	4#	71#
264.2	6#	70#
307.5	3#	71#
t	$\binom{5893}{4341}$	$\binom{5893}{4047}$
28.4*	81#	106#
49.1	81#	105#
85.8	77#	102#
113.8	78#	102#
173.9	77#	99#†
206.8	74#	97#
264.2	71#	91#
307.5	72#	93#

* At 28.4°, $\binom{6708}{5893} = 27\#$, $\binom{5893}{4861} = \binom{D}{F} = 47\#$.

† Assumes $n_{4047} = 1.4023$ instead of 1.4923.

28. B = $\mathbf{C_2H_6O}$, Ethyl alcohol (38); $t = 15°C$; for all values of % B, $\binom{6708}{5893} = 221 \pm 6$, $\binom{5893}{5351} = 185 \pm 6$

45. B = $\mathbf{C_5H_4O_2}$, 2-Furaldehyde (132)

% B	$\binom{6563}{5876}$	$\binom{5876}{4861}$	t
4.6217	213	480	24.05
	212	474	37.85
5.6935	219	496	23.8
	219	496	35.4
6.5624	224	502	21.75
	224	503	31.85
96.3400	719	1912	23.7
	714		30.3
100.000	744	1971	22.1
	735	1954	32.3
	729	2031	46.5
	700	1973	75.0

67. B = $\mathbf{Pb(NO_3)_2}$; $t = 18°C$ (86)

N	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.5	195	355	443
1.0	209	372	478
2.0	235	535	

68. B = $\mathbf{Pb(C_2H_3O_2)_2}$, Acetate; $t = 18°C$ (65)

N	$\binom{4679}{3256}$	$\binom{3612}{3256}$
0.4971	1611	618
0.9725	1741	726
2.006	2004	790
N	$\binom{3405}{3256}$	$\binom{3256}{2981}$
0.4971	288	731
0.9725	313	760
2.006	368	914

73. B = $\mathbf{CdCl_2}$ (Pulfrich); $t = 25°C$ (49)

% B	$\binom{C}{D}$	$\binom{D}{F}$
1.599	192	418
4.472	174	432
8.620	207	436
11.600	230	434
18.690	206	505
21.201	218	493
26.076	219	530
31.090	244	548
41.540	274	623

76. B = $\mathbf{CdBr_2}$ (Pulfrich); $t = 25°C$ (49)

1.05	287	561
2.76	193	415
5.41	167	457
11.03	183	465
15.66	192	508
21.13	212	540
27.51	243	560
40.74	243	690

77. B = $\mathbf{CdI_2}$ (Pulfrich); $t = 25°C$ (49)

0.834	182	436
3.340	166	437
3.880	233	413
6.984	207	471
13.491	209	448
20.133	268	572
26.785	286	669
39.860	306	848

79. B = $\mathbf{HgCl_2}$; $t = 18°C$ (86)

N	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.3	186	417	339
0.5	190	433	336

80. B = $\mathbf{Cu(ClO_3)_2}$; $t = 18°C$ (86)

N	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.5	189	431	340
1	192	444	350
2		448	378

81. B = $\mathbf{Cu(NO_3)_2}$; $t = 18°C$ (86)

0.5	193	438	341
1	202	457	362
2		499	402

84. B = $\mathbf{MnCl_2}$; $t = 18°C$ (86)

0.5	189	429	336
1	194	445	351
2	206	471	382
6	249	583	475

N (65)	$\binom{4679}{3256}$	$\binom{3612}{3256}$
0.4995	1546	591
1.013	1625	616
2.024	1738	665
4.042	1968	753
N (65)	$\binom{3405}{3256}$	$\binom{3256}{2981}$
0.4995	273	652
1.013	284	682
2.024	308	735
4.042	352	841
N (65)	$\binom{3256}{2749}$	$\binom{3256}{2574}$
0.4995	1395	2142
1.013	1461	2244
2.024	1583	2441
4.042	1815	2816

N (65)	$\binom{3256}{2314}$
0.4995	3769
1.013	3966
2.024	4336
4.042	4998

85. B = $\mathbf{MnBr_2}$; $t = 18°C$ (86)

N	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.5	193	444	348
1	204	470	377
2	225	522	422
4	263	633	506

87. B = $\mathbf{Mn(NO_3)_2}$; $t = 18°C$ (86)

0.5	190	434	339
1	198	453	355
2	214	482	403

88. B = $\mathbf{FeCl_2}$; $t = 18°C$ (86)

0.5	189	435	332
1	196	457	
2	183	524	
4	183	610	

89. B = $\mathbf{FeCl_3}$; $t = 18°C$ (86)

N	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.5	196	447	
1	209	480	
2	235	560	
4	293		

90. B = $\mathbf{FeBr_2}$; $t = 18°C$ (86)

0.5	195	444	351
1	206	472	373
2	231	529	
4	271	631	
5	296	689	

92. B = $\mathbf{Fe(NO_3)_3}$; $t = 18°C$ (86)

0.5	196	450	
1	207	479	
2	232	535	
4	282	654	

93. B = $\mathbf{CoCl_2}$; $t = 18°C$ (86)

0.5	193	433	340
1	199	450	351
2	211		
4	234		

94. B = $\mathbf{Co(ClO_3)_2}$; $t = 18°C$ (86)

0.5	189	426	330
1	192	431	342
2	201	449	358
4	218		
5	235		

95. B = $\mathbf{CoBr_2}$; $t = 18°C$ (86)

0.5	194	444	345
1	208	472	368
2	228	526	410
4	273		

97. B = $\mathbf{Co(NO_3)_2}$; $t = 18°C$ (86)

0.5	189	431	344
1	196	447	357
2	211		
4	239		
5	243		

98. B = $\mathbf{NiCl_2}$; $t = 18°C$ (86)

0.5	189	434	340
1	197	450	
2		493	
4		545	

N (65)	$\binom{4679}{3256}$	$\binom{3405}{3256}$
0.4960	1555	274
1.002	1622	286
2.037	1752	311
4.014	2021	359
N (65)	$\binom{3256}{2981}$	$\binom{3256}{2749}$
0.4960	655	1400
1.002	684	1470
2.037	744	1603
4.014	848	1852

98.—(*Continued*)

N (65)	$\binom{3256}{2574}$	$\binom{3256}{2314}$
0.4960	2149	3784
1.002	2260	3991
2.037	2471	4391
4.014	2878	

99. B = $\mathbf{Ni(ClO_3)_2}$; t = 18°C (86)

N	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.5	189	426	330
1	190	436	340
2	197	456	
4		502	

99.1. B = $\mathbf{NiBr_2}$; t = 18°C (86)

0.5	196	443	346
1	205	473	376
2	225	530	
4		656	

101. B = $\mathbf{Ni(NO_3)_2}$; t = 18°C (86)

0.5	190	433	336
1	197	451	
2		488	
4		560	
6		631	

102. B = $\mathbf{CrCl_3}$; t = 18°C (86)

0.3	197	416	307
0.5	189	434	
1	199	454	
2	215	500	

103. B = $\mathbf{CrBr_3}$; t = 18°C (86)

0.5	194	450	
1	207	578	
2	224	554	

110. B = $\mathbf{AlCl_3}$; t = 18°C (86)

0.5	188	431	333
1	194	444	345
2	204	473	370
4	225	534	406

112. B = $\mathbf{Al(NO_3)_3}$; t = 18°C (86)

0.5	189	433	335
1	196	449	350
2	207	483	375
4	232	547	436
6	257	608	488

114. B = $\mathbf{BeCl_2}$; t = 18°C (86)

0.5	187	427	331
1	191	440	339
2	200	464	356
4	214	513	394

115. B = $\mathbf{Be(NO_3)_2}$; t = 18°C (86)

0.5	189	428	337
1	195	443	351
2	205	474	373
4	225	532	423

122. B = $\mathbf{MgCrO_4}$; t = 18°C (86)

N	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.5	213		
1	240		
2	296		
4	401		
5	464		

145. B = $\mathbf{LiClO_3}$; t = 18°C

N (65)	$\binom{4679}{3256}$	$\binom{3612}{3256}$
0.5124	1518	579
1.023	1544	587
2.043	1567	580
4.090	1697	648
N (65)	$\binom{3405}{3256}$	$\binom{3256}{2981}$
0.5124	264	635
1.023	270	646
2.043	249	699
4.090	299	701
N (65)	$\binom{3256}{2749}$	$\binom{3256}{2574}$
0.5124	1359	2081
1.023	1386	2123
2.043	1463	2228
4.090	1531	2352

149. B = $\mathbf{Li_2SO_4}$; t = 18°C (65)

N	$\binom{4679}{3256}$	$\binom{3612}{3256}$
0.4307	1507	576
0.871	1514	578
1.744	1532	582
3.493	1568	597
N	$\binom{3405}{3256}$	$\binom{3256}{2981}$
0.4307	265	631
0.871	266	638
1.744	268	643
3.493	275	655
N	$\binom{3256}{2749}$	$\binom{3256}{2574}$
0.4307	1343	2057
0.871	1351	2071
1.744	1370	2092
3.493	1398	2134

t = 18° C(86)

N	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.5	185	420	329
1	186	425	333
2	191	432	340
4	199	440	344

151. B = $\mathbf{LiC_2H_3O_2}$, Acetate; t = 18°C (65)

N	$\binom{4679}{3256}$	$\binom{3612}{3256}$
0.4885	1529	584
1.047	1571	600
2.022	1741	420
4.033	1791	681

151.—(*Continued*)

N	$\binom{3405}{3256}$	$\binom{3256}{2981}$
0.4885	269	642
1.047	278	661
2.022	291	699
4.033	314	761
N	$\binom{3256}{2749}$	$\binom{3256}{2574}$
0.4885	1385	2116
1.047	1418	2201
2.022	1499	2332
4.033	1634	2588

152. B = $\mathbf{LiCNS}$; t = 18°C (65)

N	$\binom{4679}{3256}$	$\binom{3612}{3256}$
0.5109	1646	631
1.031	1796	696
2.082	2105	824
3.465	2514	983
N	$\binom{3405}{3256}$	$\binom{3256}{2981}$
0.5109	293	703
1.031	321	783
2.082	383	941
3.465	464	1115
N	$\binom{3256}{2746}$	
0.5109	1525	
1.031	1716	
2.082	2081	
3.465	2497	

153. B = $\mathbf{Li_2CrO_4}$; t = 18°C (86)

N	$\binom{C}{D}$	$\binom{D}{F}$	
0.5	210	512	
1	238		
2	292		
4	402		

154. B = $\mathbf{Li_2Cr_2O_7}$; t = 18°C (86)

0.3	207		
0.5	224		
1	267		

181. B = $\mathbf{NaC_{16}H_{31}O_2}$, Palmitate; t = 70°C (85)

g B/l soln.	$\binom{C}{D}$	$\binom{D}{F}$
Pure, prepared from pure acid and alkali		
30.4	183	425
40.7	169	426
51.9	196	430
62.3	184	427
Purified commercial material		
28.9	214	400
33.7	180	406
45.2	183	420
52.3	186	404
64.7	189	418
72.1	178	416
86.8	171	426

182. B = $\mathbf{NaC_{18}H_{33}O_2}$, Oleate; t = 70°C (85)

g B/l soln.	$\binom{C}{D}$	$\binom{D}{F}$
0.0	175	431
38.8	200	413
49.7	188	425
69.2	181	426
100.4	182	381
126.8	189	431
149.0	213	430
177.5	246	408

183. B = $\mathbf{NaC_{18}H_{35}O_2}$, Stearate; t = 70°C (85)

0.0	175	431
24.2	170	400
28.4	176	407
35.7	177	422
44.9	184	400

191. B = $\mathbf{Na_2CrO_4}$; t = 18°C (86)

N	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.3	201	470	
0.5	213		
1	242		
2	296		

193. B = $\mathbf{KCl}$; t = 18°C (Abbe) (14)

1	19#	44#	33#
2	20#	47#	35#
3	20#	48#	38#

209. B = $\mathbf{KC_{16}H_{31}O_2}$, Palmitate; t = 70°C (85)

g B/l soln.	$\binom{C}{D}$	$\binom{D}{F}$
0.0	175	431
33	174	420
38.2	179	416
47.3	166	417
56.2	170	425
66.3	162	419
75.7	161	436
91.5	180	419

217. B = $\mathbf{K_3Fe(CN)_6}$; t = 18°C (86)

N	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.5	195	467	
1	210	519	
2	238	620	

218. B = $\mathbf{K_4Fe(CN)_6}$; t = 18°C (86)

0.5	194	447	345
1	204	480	361
2	227	525	404

219. B = $\mathbf{K_2CrO_4}$; t = 18°C (86)

0.3	201	474	
0.5	213	513	
1	242		
2	292		
4	397		

220. B = $K_2Cr_2O_7$; t = 18°C (86)

N	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.3	208		
0.5	224		

227. B = CsBr; t = 18°C (86)

227.—(*Continued*)

N	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.5	193	442	346
1	203	465	370
2	223	514	420
4	263	613	504

228. B = $CsNO_3$; t = 18°C (86)

N	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.3	187	424	333
0.5*	190	458	312
1	195	444	352

* $\binom{D}{G'}$ = 770.

IIa. Non-Aqueous Binary Mixtures: Inorganic

S

229. B = Se; t is not stated (88)

% B	$\binom{6708}{5893}$	$\binom{5893}{5351}$	% B	$\binom{6708}{5893}$	$\binom{5893}{5351}$
0.0	20##	20##	57.0	48##	57##
9.0	22##	24##	64.0	57##	68##
17.6	25##	29##	70.0	65##	80##
25.0	28##	32##	75.0	73##	
31.8	32##	36##	80.0	90##	
37.5	34##	39##	87.7	124##	
43.2	38##	44##	93.8	155##	
48.2	43##	47##	99.2	200##	
53.0	45##	52##	100	204##	

IIb. Non-Aqueous Binary Mixtures: ℭ-Table, the ℭ-Arrangement

The A-Component is a C-Compound

CCl_4

Carbon tetrachloride

232. B = $C_2H_4O_2$, Acetic acid (137)

% A	$\binom{6563}{5893}$	$\binom{5893}{4961}$	$\binom{4961}{4358}$	t
21.319	209	514	363	13.0
21.319	208	491	375	24.5
21.319	205	492	357	40.3
41.728	236	523	395	13.3
41.728	215	518	386	39.5
41.728	214	507	370	57.0
64.436	214	585	453	14.5
64.436	515*	573	454	22.5
64.436	221	565	442	34.1
100.000	287	700	554	10 7
100.000	283	682	555	23.8
100.000	279	661	549	37.1

* Possibly it should be 215.

235. B = C_6H_6, Benzene; t = 25°C (70)

% A	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.000	464	1190	1030
16.873	447	1142	985
31.954	428	1090	938
43.419	413	1044	895
55.495	389	991	847
64.704	373	939	804
71.042	358	906	770
79.671	334	845	714
87.689	309	780	660
98.504	289	731	615
100.000	268	668	554

CS_2

Carbon disulfide

237. B = $SnCl_4$, Stannic chloride (135)

% B	$\binom{6563}{5876}$	$\binom{5876}{4861}$	$\binom{4861}{4341}$	t
0.000	961	2455	2285	19.1
0.000	956	2418	2742*	28.3
13.8282	935	2337		25.7
13.8282	908	2276		34.1
27.2410	863	2177		24 9
27.2410	855	2151		34.1
38.6050	821	2055		23.7
38.6050	820	2075		34.1
44.3085	786	1977		24.2
44.3085	759	1971		36.1
66.3864	656	1653		26.2
66.3864	656	1663		35.5
80.7152	586	1459		25.1
80.7152	580	1443		37.4
100.000	368	1102		27.1
100 000	446	1107		42.7

* Surely wrong.

238. B = $CHCl_3$, Chloroform (135)

0.000	961	2455	2285	19.1
0.000	956	2418	2742*	28.3
19.1533	839	2163	1906	27.8
19.1533	829	2068	1885	35.7
34.8063	740	1805	1629	26.6
34.8063	703	1786	1622	33.1
50.6210	603	1499	1350	26.1
50.6210	597	1495	1343	36.4
58.9405	550	1346	1200	26.0
58.9405	539	1343		36.5
75.7576	438	1038	913	28.5
75.7576	417	1042	889	33.8
100.000	251	626	514	22.7
100 000	255	610	513	35.4

* Surely wrong.

239. B = $C_2H_4O_2$, Acetic acid (133, 136)

% B	$\binom{6563}{5893}$	$\binom{5893}{4961}$	$\binom{4961}{4358}$	t
0.000	963	2530	2274	6.8
0.000	940	2486	2256	20.9
0.000	910	2429	2208	34.5
12.076	806	2133		11.9
12.076	788	2108	1900	23.1
12.076	756	2039	1836	44.3
61.284	416	1045	896	13.9
61.284	406	1040	890	21.1
61.284	396	1009	870	35.0
80.298	300	759	601	11.5
80.298	289	735	582	23.0
80.298	292	706	568	41.2
100.000	197	475	331	21.7
100.000	196	471	327	31.7
100.000	196	462	322	49.2

240. B = $C_2H_5NO_3$, Ethyl nitrate; t = 15°C (105)

% B	$\binom{C}{F}$	$\binom{F}{G'}$
0.00	3426	2273
46.73	1956	1260

241. B = C_2H_6O, Ethyl alcohol; t = 20°C (134)

% B	$\binom{C}{F}$	$\binom{F}{G'}$
0.000	3421	2247
20.182	2508	1623
31.966	2085	1328
49.234	1589	1002
100.000	611	350

242. B = C_3H_6O, Acetone; t = 25°C (70, 71); *cf.* (152)

% A	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.000	187	476	398
13.245	243	601	524
29.326	317	807	716
40.329	385	966	857
51.761	477	1134	1084
51.799	459	1164	1105
51.902	452	1168	1032
71.137	599	1571	1398
83.283	718	1899	1702
86.892	763	2012	1814
100.000	917	2473	2243

243. B = $C_3H_8O_2$, Methylal; t = 25°C (70, 71)

0.000	148	407	334
12.921	225	566	476
28.682	307	776	685
38.408	366	926	817
45.630	410	1049	932
53.139	463	1193	1064
60.034	524	1336	1179
62.38	533	1392	1234
65.262	559	1458	1246
75.141	649	1697	
86.449	764	2025	1815
100.000	917	2473	2243

244. B = $C_4H_8O_2$, Isobutyric acid (133, 136)

% B	$\binom{6563}{5893}$	$\binom{5893}{4961}$	$\binom{4961}{4358}$	t
0.000	963	2530	2274	6.8
0.000	940	2486	2256	20.9
0.000	910	2429	2208	34.5
20.336	719	1920	1705	11.75
20.336	726	1884	1703	19.5
20.336	730	1841	1674	34.5
45.276	514	1338	1267	11.2
45.276	495	1326	1256	18.2
45.276	482	1313	1217	30.8
68.028	349	936	914	13.2
68.028	337	945	896	18.4
68.028	344	915	879	38.0
100.000	198	481	504	9.1
100.000	191	473	494	25.9
100.000	184	466	486	39.4
100.000	178	453	466	68.4

245. B = $C_4H_{10}O$, Isobutyl alcohol (133, 135)

15.803	754	1990	1772	9.6
15.803	737	1932	1722	28.9
15.803	725	1903	1703	39.7
30.008	627	1614	1422	8.3
30.008	606	1567	1379	25.2
30.008	607	1552	1376	33.6
50.220	474	1169	1039	11.8
50.220	456	1205	982	22.1
70.388	338	856	742	9.5
70.388	319	840	701	22.4
100.000	180	496	380	23.7
100.000	179	491	376	34.9

246. B = $C_4H_{10}O$, Ethyl ether (135)

% B	$\binom{6563}{5876}$	$\binom{5876}{4861}$	$\binom{4861}{4341}$	t
0.000	961	2455	2285	19.1
0.000	956	2418	2742*	28.3
20.3505	700	1742	1568	24.0
20.3505	687	1725	1545	30.2
29.6571	606	1495	1352	25.4
29.6571	594	1481	1366	30.3
41.5400	495	1237	1108	24.4
41.5400	501	1236	1075	30.3
59.9864	377	904	783	25.3
59.9864	365	900	773	30.6
79.7398	269	635	561	25 7
100.000	186	422	347	24.8
100.000	186	420	346	29.7

* Surely wrong.

247. B = $C_5H_{10}O_2$, Isovaleric acid (133, 136)

% B	$\binom{6563}{5893}$	$\binom{5893}{4961}$	$\binom{4961}{4358}$	t
28.295	673	1727	1519	9.5
28.295	637	1680	1513	20.3
28.295	629	1660	1498	32.0
45.900	529	1337	1168	8.0
45.900	508	1308	1151	19.8
45.900	504	1296	1164	26.6
62.573	395	1029	888	11.2
62.573	404	1003	890	20.5
62.573	393	976	856	37.7
100 000	212	495	539	8.1
100.000	204	481	536	28.3
100.000	201	508	488	41.9
100.000	195	491	482	57.0

$CHCl_3$

Chloroform

249. B = $C_2H_4O_2$, Acetic acid (137)

% A	$\binom{6563}{5893}$	$\binom{5893}{4961}$	$\binom{4961}{4358}$	t
27.584	159	552	369	12.9
27.584	201	501	363	22.0
27.584	199	491	369	39.4
50.994	179	581	412	12.1
50.994	210	531	404	22.8
50.994	230	513	390	39.2
68.619	230	569	438	13.0
68.619	220	557	432	24.0
68.619	216	549	430	43.9
80.763	240	583	455	10.0
80.763	240	381*	656*	21.6
80.763	257†	560	434	41.8

* Probably n_{4961} should be 1.42954 instead of 1.42754.

† Assumes $n_{6563} = 1.40968$ instead of 1.42968.

250. B = C_2H_6O, Ethyl alcohol (137)

0.000	172	438	356	10.8
0.000	170	434	347	18.7
0.000	164	420	344	47.5
19.522	181	462	364	8.7
19.522	173	448	361	24.9
19.522	175	449	360	30.2
27.661	186	468	384	10.0
27.661	176	469	368	25.0
27.661	179	456	366	33.0
34.824	205	446	387	6.2
34.824	190	482	382	17.3
34.824	186	474	384	36.6
49.079	194	516	410	11.0
49.079	189	515	405	22.4
49.079	188	499	496	35.8
60.901	212	532	420	10.5
60.901	207	520	409	24.2
60.901	203	510	410	31.3
78.429	231	568	446	7.3
78.429	226	578	441	17.4
78.429	209	579	439	36.5
87.414	225	584	426	11.8
87.414	227	585	454	24.0
87.414	231	568	431	37.5
100.000	255	633	508	10.1
100.000	252	624	515	25.2
100.000	248	613	497	43.5

251. B = C_3H_6O, Acetone (137); *cf.* (70, 152)

0.000	198	478	396	9.6
0.000	195	471	392	20.4
0.000	193	465	385	37.4
22.396	208	499	417	10.6
22.396	195	491	410	24.4
22.396	195	466	399	36.0
41.577	215	522	448	11.7
41.577	211	510	423	28.0
41.577	214	501	414	36.2
56.889	223	547	456	10.2
56.889	229	547	476	21.0
56.889	215	511	392	36.5
84.064	238	600	536	12.4
84.064	206	627	453	20.0
84.064	231	580	469	36.3
93.901	253	625	562	12.2
93.901	277	592	562	19.0
93.901	239	510	567	31.2

251.—(*Continued*)

$t = 25°C$ (70); *cf.* (71, 152)

% A	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.000	186	470	393
16.664	193	487	403
33.039	206	503	414
45.832	210	516	427
56.298	214	532	443
64.507	222	551	455
72.276	226	562	471
79.884	233	578	480
88.409	241	595	497
94.292	250	610	508
100.000	252	623	523

CH_2I_2

Methylene iodide

252. B = $C_6H_{10}O_4$, Diethyl oxalate; $t = 15°C$ (105)

% A	$\binom{C}{F}$	$\binom{F}{G'}$
0.00	745	435
75.50	1985	1306
100.00	3766	2691

$C_2H_4Cl_2$

Ethylene chloride

306. B = $C_2H_4O_2$, Acetic acid (137)

% A	$\binom{6563}{5893}$	$\binom{5893}{4961}$	$\binom{4961}{4358}$	t
26.593	210	499	359	9.0
26.593	204	497	355	21.2
26.593	200	474	336	41.8
46.948	218	527	393	9.7
46.948	213	513	393	20.2
46.948	209	496	383	37.2
69.568	223	546	407	8.6
69.568	222	543	412	23.5
69.568	217	527	398	42.0
88.390	233	581	449	9.0
88.390	234	569	436	28.5
88.390	239	553	401	52.3

307. B = C_3H_6O, Acetone (137)

26.844	205	498	383	9.8
26.844	200	490	398	23.8
51.575	213	529	419	7.8
51.575	209	526	415	20.3
72.414	225	558	437	9.8
72.414	225	536	450	25.9
86.874	234	576	453	12.1
86.874	219	585	436	23.3
100.000	250	609	477	9.7
100.000	247	603	467	25.4
100.000	246	578	454	43.0

$C_2H_4O_2$

Acetic acid

310. B = C_4H_9Br, Butyl bromide (137)

% B	$\binom{6563}{5893}$	$\binom{5893}{4961}$	$\binom{4961}{4358}$	t
21.961	192	516	361	14.1
21.961	212	504	367	24.4
21.961	195	503	351	44.4
43.647	219	547	400	13.5
43.647	220	533	397	24.0
43.647	223	527	399	36.1
68.091	237	599	449	13.2

310.—(*Continued*)

% B	$\binom{6563}{5893}$	$\binom{5893}{4961}$	$\binom{4961}{4358}$	t
68.091	230	585	437	40.7
100.000	274	693	528	10.4
100.000	276	683	522	26.0
100.000	247	662	504	58.8

312. B = C_6H_6, Benzene

$t = 25°C$ (70, 71); *cf.* (152)

% A	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.000	465	1191	1030
11.634	436	1105	953
23.614	403	1016	873
34.008	375	943	812
44.857	345	863	736
54.459	318	796	672
63.968	287	732	615
73.819	265	655	548
82.321	244	593	494
91.338	220	529	431
100.000	197	466	376

C_2H_5Br

Ethyl bromide

316. B = C_3H_6O, Acetone (137)

% A	$\binom{6563}{5893}$	$\binom{5893}{4961}$	$\binom{4961}{4358}$	t
0.000	198	478	396	9.6
0.000	195	471	392	20.4
33.110	191	510	407	16.9
33.110	212	490	426	28.7
50.812	239	532	429	16.3
50.812	224	519	447	28.3
67.809	252	559	473	16.8
67.809	273	538	467	24.7
100.000	291	651	561	16.0
100.000	289	638	564	32.1

C_2H_5I

Ethyl iodide

317. B = $C_4H_8O_2$, Ethyl acetate; $t = 25°C$ (70, 71); *cf.* (152)

% A	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.000	183	450	371
19.082	207	417	510
35.007	231	571	474
49.517	259	643	539
59.741	282	710	594
68.529	310	774	657
74.566	328	827	703
82.792	364	911	779
89.093	393	993	850
94.970	420	1080	925
100.000	458	1166	1002

$C_2H_5NO_3$

Ethyl nitrate

318. B = C_7H_{16}, Heptane (105)

% B	$\binom{C}{F}$	$\binom{F}{G'}$	t
0.00	811	479	16.2
38.16	745	425	15

319. B = $C_{10}H_7Br$, α-Bromonaphthalene; $t = 15°C$ (105)

59.99	1989	1312
100.00	3269	2218

C_2H_6O

Ethyl alcohol

326. B = $C_6H_8O_2$, Cyclohexan-1, 4-dione (26)

% B	$\binom{C}{G'}$	t
0.00	962	16.8
7.55	979	17.5
8.08	988	17.4

328. B = $C_9H_6Br_2O_2$, Dibromocinnamic acid; $t = 25°C$ (151)

% B	$\binom{C}{D}$
0.000	180
5.205	191

329. B = $C_9H_7BrO_2$, α-Bromocinnamic acid; $t = 25°C$ (151)

0.000	180
4.677	198
5.041	190
5.192	200

330. B = $C_9H_7BrO_2$, β-Bromocinnamic acid; $t = 25°C$ (151)

0.000	180
4.512	197
4.877	192

331. B = $C_9H_7BrO_2$, α-Bromoallocinnamic acid; $t = 25°C$ (151)

0.000	180
4.824	198
5.248	200
5.320	202

332. B = $C_9H_7BrO_2$, β-Bromoallocinnamic acid; $t = 25°C$ (151)

0.000	180
5.044	195

333. B = $C_9H_7ClO_2$, α-Chlorocinnamic acid; $t = 25°C$ (151)

0.000	180
4.984	206
5.136	206
5.190	207
5.469	206

334. B = $C_9H_7ClO_2$, α-Chloroallocinnamic acid; $t = 25°C$ (151)

0.000	180
5.008	198
5.051	197
5.260	200

338. B = $C_{12}H_{12}O_2$, 2-Benzoylcyclopentanone (9)

% B	$\binom{C}{D}$	$\binom{D}{F}$	t
0.000	172	407	25.0
4.520	202	496	25.0
6.454	212	532	25.2

C_2H_6O.—(*Continued*)

339. B = $C_{13}H_{14}O_2$, 2-Benzoylcyclohexanone (9)

% B	$\binom{C}{D}$	$\binom{D}{F}$	t
0.000	172	407	25.0
2.567	185	428	24.8
2.835	177	428	24.8

C_3H_6O

Acetone

349. B = C_3H_8O, Isopropyl alcohol (98)

$n_F^{22} = n_C^{22} + 0.00663$ if $0 < \%\,B < 100$

C_5H_5N

Pyridine

372. B = $C_{10}H_8$, Naphthalene (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$	t
0.000	426	1231	1022	16.8
9.413	477	1316	1123	16.9
29.426	531	1524	1363	17.0
100.000	746	2110	1933	99.6

$C_5H_{10}O_2$

Propyl acetate

375. B = $C_5H_{10}O_2$, Ethyl propionate (92)

$n_F^{20} = n_D^{20} + 0.01354$ if $0 < \%\,B < 100$

$n_{G'}^{20} = n_F^{20} + 0.01191$ if $0 < \%\,B < 100$

$C_6H_4Br_2$

m-Dibromobenzene

377. B = C_9H_7N, Quinoline (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$	t
0.000	825	2299	2114	9.6
52.574	727	2030*	1836*	9.4
0.000	815	2294	2102	14.8
29.635	773	2175	1952	14.8

* If $n_F = 1.64599$ instead of 1.65599.

$C_6H_5NO_2$

Nitrobenzene

379. B = C_6H_7N, Aniline; $t = 20°C$ (16)

% B	$\binom{C}{D}$
0.00	688
16.77	704
29.27	709
46.14	714
62.49	709
77.25	704
100.00	684

380. B = $C_{10}H_8$, Naphthalene (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$	t
0.000	682	1869		13.5
8.875	694	1898		14.6
20.327	700	1965		14.6
100.000	746	2110	1833	99.6

381. B = $C_{10}H_9N$, α-Naphthylamine; $t = 20.8°C$ (76)

% B	$\binom{C}{D}$	% B	$\binom{C}{D}$
0.000	648	8.943	709

C_6H_6

Benzene

383. B = $C_7H_7NO_2$, *m*-Nitrotoluene (33)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{C}{D}$	$\binom{D}{F}$
	$t = 15°C$		$t = 30°C$	
0.0	487	1194	483	1187
30.5	543	1371	509	1362
50.4	573	1501	564	1493
72.4	604	1607	592	1605
87.8	637	1698	621	1695
100.0	653	1766	636	1761

384. B = C_7H_9N, *m*-Toluidine (33)

0.0	487	1194	483	1187
25.1	522	1312	523	1289
48.3	560	1409	551	1392
67.1	581	1512	573	1478
84.2	598	1589	594	1547
100.0	620	1657	619	1610

385. B = C_7H_{16}, Heptane; $t = 15°C$ (105)

% A	$\binom{C}{F}$	$\binom{F}{G'}$
56.26	1158	718
100.00	1705	1068

386. B = $C_8H_{18}O$, 1-β-Octanol; $t = 20°C$ (34)

$\binom{6708}{5896} = 10[55 - 0.30(\%\,B)]$; $\binom{5896}{5790} = 10[8 - 0.04(\%\,B)]$; $\binom{5790}{5461} = 10[32 - 0.19(\%\,B)]$; $\binom{5461}{4358} = 10[178 - 1.25(\%\,B) + 0.0022(\%\,B)^2]$; $\binom{4358}{4046} = 10[85 - 0.53(\%\,B)]$; for density, *see* Table 1.

390. B = $C_{10}H_{20}O_2$, 1-β-Octyl acetate; $t = 20°C$ (34)

$\binom{6708}{5896} = 10[55 - 0.31(\%\,B)]$; $\binom{5896}{5790} = 10[8 - 0.04(\%\,B)]$; $\binom{5790}{5461} = 10[32 - 0.19(\%\,B)]$; $\binom{5461}{4358} = 10[178 - 1.15(\%\,B) + 0.0010(\%\,B)^2]$; $\binom{4358}{4046} = 10[85 - 0.52(\%B)]$; for density, *see* Table 1.

394. B = $C_{27}H_{44}$, α-Cholesterylene; $t = 20°C$ (24)

% B	$\binom{C}{D}$
0.00	478
6.639	461
10.412	459

395. B = $C_{27}H_{46}$, Cholestene; $t = 20°C$ (24)

0.000	478
10.104	442
17.979	450

396. B = $C_{27}H_{46}O$, Cholesterol; $t = 20°C$ (24)

0.000	478
6.018	466
6.628	471

397. B = $C_{27}H_{48}$, Cholestane; $t = 20°C$ (24)

0.000	478
6.151	461

398. B = $C_{29}H_{48}OS_2$, Methyl cholesterylxanthogenate; $t = 20°C$ (24)

0.000	478
6.772	461
11.355	474

399. B = $C_{29}H_{50}OS_2$, Methyl dihydrocholesterylxanthogenate; $t = 20°C$ (24)

0.000	478
10.987	455
15.665	451

C_6H_7N

Aniline

400. B = C_9H_7N, Quinoline (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$	t
0.000	651	1830	1637	20.7
83.321	805	2227	2061	20.8
90.291	813	2256	2074	20.9
100.000	816	2279	2100	20.7

401. B = $C_{10}H_8$, Naphthalene (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	t
0.000	663	1824	16.5
9.998	685	1871	17.2

402. B = $C_{10}H_9N$, α-Naphthylamine; $t = 21.1°C$ (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.000	651	1824	1637
10.880	702	1964	1788

C_6H_{12}

Cyclohexane

404. B = $C_7H_7NO_2$, *m*-Nitrotoluene (33)

% B	$\binom{C}{D}$	$\binom{D}{F}$
	$t = 15°C$	
0.0	225	544
29.8	351	912
50.0	435	1157
70.4	540	1396
86.8	608	1609
100.0	653	1766
	$t = 30°C$	
0.0	223	550
29.8	351	910
50.0	424	1154
70.4	513	1399
86.8	568	1607
100.0	636	1761

405. B = C_7H_9N, *m*-Toluidine (33)

	$t = 15°C$	
0.0	225	544
24.1	323	819
45.7	404	1054
61.7	470	1225
82.4	541	1457
100.0	620	1657
	$t = 30°C$	
0.0	223	550
24.1	303	816
45.7	409	1029
61.7	463	1213
82.4	538	1420
100.0	619	1610

$C_6H_{12}O_2$

Isobutyl acetate

406. B = $C_7H_{14}O_2$, Ethyl isovalerate; $t = 20°C$ (92)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.0000	566	1349	1193
18.7251	560	1352	1211
31.3151	550	1372	1216
48.3989	562	1358	1206
64.4828	562	1354	1205
77.1855	561	1360	1225
100.0000	565	1352	1225

$C_6H_{12}O_2$

Ethyl butyrate

407. B = $C_6H_{12}O_2$, Ethyl isobutyrate; $t = 20°C$ (92)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.0000	550	1357	1208
25.4236	543	1358	1216
49.0035	540	1365	1204
74.2817	540	1362	1190
100.0000	537	1348	1212

C_6H_{14}

Hexane

408. B = $C_7H_7NO_2$, *m*-Nitrotoluene (33)

% B	$\binom{C}{D}$	$\binom{D}{F}$
t = 15°C		
0.0	177	484
28.3	306	858
53.1	421	1166
69.7	507	1377
86.6	613	1602
100.0	653	1766
t = 30°C		
0.0	177	479
28.3	306	849
53.1	433	1148
69.7	499	1380
86.6	578	1594
100.0	636	1761

409. B = C_7H_9N, *m*-Toluidine (33)

% B	$\binom{C}{D}$	$\binom{D}{F}$
t = 22°C		
0.0	177	484
27.7	297	805
44.9	384	995
63.1	453	1208
83.1	554	1447
100.0	620	1639
t = 32°C		
0.0	177	479
27.7	307	787
44.9	362	988
63.1	450	1196
83.1	545	1413
100.0	619	1604

C_7H_6O

Benzaldehyde

410. B = C_9H_7N, Quinoline (76)

% A	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$	*t*
0.000	820	2293	2088	14.9
17.090	782	2187	1994	14.8

$C_7H_6O_2$

Benzoic acid

411. B = C_9H_7N, Quinoline (76)

% A	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$	*t*
0.000	813	2284	2096	19.1
40.079	723	1982	1803	19.1
0.000	813	2273	2082	21.6
13.418	776	2193	1971	21.6
45.882	695	1934		21.5
0.000	809	2277	2085	25.0
10.202	787	2205	2001	24.6

C_7H_7Br

Benzyl bromide

412. B = C_7H_7Cl, Benzyl chloride; *t* = 20°C (92)

% A	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.0000	502	1207	1017
18.8772	511	1245	1085
23.3439	519	1250	1094
33.0428	512	1274	1087
48.0849	513	1301	1117
65.3828	530	1319	1136
73.9944	538	1329	1143
78.9757	532	1348	1150
100.0000	552	1366	1180

$C_7H_7NO_2$

m-Nitrotoluene

413. B = C_7H_8, Toluene (33)

% B	$\binom{C}{D}$	$\binom{D}{F'}$
t = 15°C		
0.0	653	1766
14.4	617	1686
30.7	604	1572
49.6	540	1472
72.7	519	1315
100.0	469	1145
t = 30°C		
0.0	636	1761
14.4	608	1681
30.7	570	1591
49.6	546	1469
72.7	500	1328
100.0	453	1170

414. B = C_7H_{14}, Methylcyclohexane (33)

t = 15°C		
0.0	653	1766
15.3	595	1572
32.3	527	1368
51.8	413	1146
73.9	340	867
100.0	230	537
t = 30°C		
0.0	636	1761
15.3	561	1574
32.3	499	1366
51.8	437	1110
73.9	330	855
100.0	223	530

C_7H_8

Toluene

415. B = C_7H_9N, *m*-Toluidine (33)

% B	$\binom{C}{D}$	$\binom{D}{F}$
t = 15°C		
0.0	469	1145
19.0	476	1237
45.9	541	1375
65.4	565	1486
82.4	586	1571
100.0	620	1657
t = 30°C		
0.0	453	1170
19.0	491	1242
45.9	522	1379
65.4	566	1457
82.4	590	1532
100.0	619	1610

416. B = $C_{12}H_{12}O_2$, 2-Benzoylcyclopentanone (9)

% B	$\binom{C}{D}$	$\binom{D}{F}$	*t*
0.000	441	1134	25.0
5.895	471	1226	25.2

417. B = $C_{13}H_{14}O_2$, 2-Benzoylcyclohexanone; *t* = 25°C (9)

% B	$\binom{C}{D}$	$\binom{D}{F}$
0.000	441	1134
3.607	443	1134
8.002	444	1146

C_7H_8O

m-Cresol

418. B = C_9H_7N, Quinoline (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$	*t*
0.000	495	1325	1143	20.4
88.167	784	2157		19.0
88.584	785	2157		20.4
100.000	812	2282		20.0
100.000	816	2288		20.5

419. B = $C_{10}H_8$, Naphthalene (76)

0.000	490	1344	1137	18.0
9.556	521	1426	1226	18.0
13.000	531	1457	1254	18.0
100.000	746	2110	1933	99.6

C_7H_8O

Anisole

420. B = C_9H_7N, Quinoline (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$	*t*
80.358	752	2096	1871	8.0
84.809	766	2125	1955	15.0
100.000	827	2299	2109	8.8
100.000	820	2294	2107	15.0

421. B = $C_{10}H_8$, Naphthalene (76)

0.000	468	1285	1153	16.5
11.013	499	1390	1206	16.6
19.089	528	1468	1287	16.8

C_7H_9N

o-Toluidine

422. B = C_9H_7N, Quinoline; *t* = 20.7°C (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.000	595	1678	1492
90.527	805	2241	2057
100.000	816	2279	2100

423. B = $C_{10}H_9N$, α-Naphthylamine; *t* = 20.7°C (76)

0.000	595	1678	1492
10.926	648	1824	1671

C_7H_9N

m-Toluidine

424. B = C_7H_{14}, Methylcyclohexane (33)

% B	$\binom{C}{D}$	$\binom{D}{F}$
t = 15°C		
0.0	620	1657
18.6	541	1450
37.9	462	1247
57.9	398	1004
78.1	319	776
100.0	230	537
t = 30°C		
0.0	619	1610
18.6	542	1417
37.9	480	1203
57.9	385	979
78.1	288	760
100.0	223	539

C_7H_{16}

Heptane

425. B = $C_{10}H_7Br$, α-Bromonaphthalene; *t* = 15°C (105)

% B	$\binom{C}{F}$	$\binom{F}{G'}$
69.46	1959	1282

C_8H_7N

Benzyl cyanide

426. B = $C_8H_{10}O$, Phenetole; *t* = 15°C (105)

% B	$\binom{C}{F}$	$\binom{F}{G'}$	*t*
0.00	1560	969	15.2
48.73	1597	996	15.0
100.00	1634	1013	14.7

C_8H_8O

Acetophenone

427. B = C_9H_7N, Quinoline (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$	*t*
77.932	754	2090	1877	14.8
100.000	820	2293	2088	14.9

428. B = $C_{10}H_8$, Naphthalene *t* = 14.9°C (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.000	524	1455	1255
13.423	557	1553	1387
14.198	569	1568	1375

429. B = $C_{10}H_9N$, α-Naphthylamine; *t* = 20.7°C (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$
0.000	507	1449
0.936	575	1636

C_8H_9Br

Bromo-*p*-xylene

430. B = C_9H_7N, Quinoline; *t* = 15.2°C (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
83.285	772	2142	1984
100.000	819	2294	2107

C_8H_{10}
Ethylbenzene

431. B = C_8H_{10}, *o*-Xylene; t = 20°C (92)

% A	$\binom{C}{D}$	$\binom{D}{F}$
0.000	445	1131
24.1074	442	1117
50.1866	437	1108
75.2146	434	1096
100.000	447	1085

432. B = C_8H_{10}, *m*-Xylene; t = 20°C (92)

0.000	468	1122
24.6565	441	1112
50.3372	442	1093
78.8580	428	1100
100.000	447	1085

433. B = C_8H_{10}, *p*-Xylene; t = 20°C (92)

0.000	465	1097
25.2055	442	1109
51.1066	441	1094
75.2683	434	1096
100.000	447	1085

C_8H_{10}
o-Xylene

434. B = C_8H_{10}, *m*-Xylene; t = 20°C (92)

% B	$\binom{C}{D}$	$\binom{D}{F}$
0.000	445	1131
24.6677	442	1130
49.5001	445	1122
74.7756	442	1121
100.0000	468	1122

435. B = C_8H_{10}, *p*-Xylene; t = 20°C (92)

0.000	445	1131
24.9410	439	1147
49.4932	446	1119
74.7171	443	1101
100.000	465	1097

C_8H_{10}
m-Xylene

436. B = C_8H_{10}, *p*-Xylene; t = 20°C (92)

% B	$\binom{C}{D}$	$\binom{D}{F}$
0.000	465	1125
24.9807	468	1104
50.2550	479	1091
75.0229	478	1107
100.000	465	1097

C_9H_7N
Quinoline

437. B = $C_9H_8N_2O$, 2-Acetylindazole (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	t
0.000	820	2277	20.4
10.013	810	2249	20.0

438. B = $C_9H_{10}O_2$, *o*-Ethylbenzoic acid (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$	t
0.000	822	2288	2088	19.1
0.000	821	2278	2105	19.8
10.659	781	2183	2007	19.8
11.817	807	2188	1982	19.1
46.712	674	1857	1658	18.9
100.000	453	1321	1122	99.6
100.000	453	1318	1065	100.0

439. B = $C_9H_{10}O_2$, Ethyl benzoate (76)

0.000	827	2299	2109	8.8
14.974	763	2129	1941	8.4

440. B = C_9H_{12}, *p*-Methylethylbenzene (76)

0.000	825	2299	2114	9.6
0.000	824	2290	2107	14.5
18.346	738	2030	1857	14.4
53.375	570	1602	1412	9.6
100.000	382	1121	933	14.6

441. B = $C_{10}H_6Cl_2$, 1, 4-Dichloronaphthalene (76)

0.000	863	2260	2098	15.0
14.297	854	2267	2108	15.0

442. B = $C_{10}H_6Cl_2$, 1, 5-Dichloronaphthalene (76)

0.000	820	2296	2110	15.7
8.541	815	2303	2102	15.8
9.835	828	2290	2111	15.6

443. B = $C_{10}H_6Cl_2$, 1, 7-Dichloronaphthalene (76)

0.000	821	2292	2105	16.1
9.195	819	2294	2116	15.8
28.217	813	2284	2110	16.0
100.000	756	2149	1884	99.5

444. B = $C_{10}H_6Cl_2$, 1, 8-Dichloronaphthalene (76)

0.000	819	2288	2109	17.4
10.086	823	2303	2123	17.4
38.683	834	2328	2168	17.4
100.000	812	2318	1880	99.8

445. B = $C_{10}H_6Cl_2$, 2, 7-Dichloronaphthalene (76)

0.000	820	2292	2105	15.9
9.984	815	2290	2101	15.9
10.510	820	2285	2101	15.9

446. B = $C_{10}H_7Cl$, β-Chloronaphthalene (76)

0.000	868	2260	2100	15.3
10.011	877	2255	2140	15.3

448. B = $C_{10}H_7I$, β-Iodonaphthalene (76)

0.000	825	2286	2091	17.2
16.824	851	2345	2165	16.8
100.000	952	2647		99.4

449. B = $C_{10}H_8$, Naphthalene (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	t
0.000	823	2285	16.8
14.438	829	2276	16.8
16.104	837	2270	16.9

450. B = $C_{10}H_8O$, α-Naphthol (76)

0.000	825	2278	19.9
10.971	852	2346	19.9
100.000	844	2420	99.3

451. B = $C_{10}H_8O$, β-Naphthol; t = 18.6°C (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0.000	816	2289	2102
9.841	845	2345	2153
15.571	853	2365	2202

452. B = $C_{10}H_9N$, α-Naphthylamine (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$	t
0.000	827	2282	2106	19.6
9.494	858	2417	2275	20.4
9.954	865	2415	2280	19.6
17.358	893	2511	2424	20.4
100.000	1088	3149		51.2
100.000	1083	3156		54.1

453. B = $C_{10}H_9N$, β-Naphthylamine (76)

0.000	823	2271	2092	22.8
9.548	858	2402	2254	22.8
10.682	863	2431		22.9
15.315	891	2468	2352	22.8
16.808	893	2489		22.9

455. B = $C_{10}H_{10}N_2$, 1, 5-Naphthylenediamine (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	t
0.000	828	2289	14.4
8.408	901	2527	13.8
9.646	897	2565	14.4

456. B = $C_{10}H_{10}N_2$, 1, 6-Naphthylenediamine (76)

0.000	813	2288	19.3
10.189	896	2513	19.3
14.498	922	2605	19.3
100.000	1312	3836	99.4

457. B = $C_{10}H_{10}N_2$, 1, 8-Naphthylenediamine (76)

0.000	813	2280	19.3
9.125	878	2486	19.2
28.692	997	2904	19.2
100.000	1285		99.4

458. B = $C_{10}H_{10}N_2$, 2, 3-Naphthylenediamine (76)

0.000	809	2277	25.0
0.000	815	2265	28.4
7.476	863	2424	26.0
8.029	870	2433	27.2

459. B = $C_{10}H_{10}N_2$, 2, 7-Naphthylenediamine (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	t
0.000	824	2298	13.0
0.000	820	2288	17.1
9.581	898	2495	12.5
9.652	895	2488	17.0

460. B = $C_{10}H_{14}$, *p*-Cymene (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$	t
0.000	823	2302	2113*	13.4
0.000	824	2294	2107	15.2
16.046	737	2058	1865	13.2
18.486	721	2020	1843	15.1
52.013	556	1573	1392	12.9
100.000	387	1036	882	16.1

* If $n_{G'}$ = 1.67473 instead of 1.66473.

461. B = $C_{10}H_{14}O$, *p*-Tolyldimethyl carbinol (76)

0.000	813	2297	2111	13.8
19.223	735	2049	1856	13.7
100.000	384	1138	945	13.5

462. B = $C_{11}H_8O$, α-Naphthaldehyde (76)

0.000	813	2277	2095	21.2
14.012	842	2388	2244	21.3
44.593	926	2603	2560	21.0
100.000	1060	3026	3134	19.3

463. B = $C_{11}H_8O$, β-Naphthaldehyde (76)

0.000	812	2279	2098	21.0
28.679	881	2450	2314	20.7
100.000	994	2879		99.4

464. B = $C_{11}H_{12}O$, 1-Keto-7-methyl-1, 2, 3, 4-tetrahydronaphthalene (76)

0.000	820	2291	2100	16.9
33.830	689	2053	1840	17.0
100.000	506	1486	1319	35.0

465. B = $C_{12}H_8O$, Diphenylene oxide (76)

0.000	818	2302	2101	13.5
12.824	835	2326	2146	13.6

466. B = $C_{12}H_{10}$, Diphenyl (76)

0.000	800	2297	2110	13.4
17.311	810	2255	2074	13.1

467. B = $C_{12}H_{12}O$, β-Naphthyl ethyl ether (76)

0.000	847	2260	2105	15.4
10.607	848	2247	2089	15.4

468. B = $C_{12}H_{13}N$, α-Ethylaminonaphthalene (76)

0.000	816	2289	2112	17.4
9.130	853	2390	2265	17.2
48.730	951	2767		16.6
100.000	1015	3026	3263	15.1

469. B = $C_{12}H_{13}N$, β-Ethylaminonaphthalene (76)

0.000	817	2270	2097	24.1
11.512	851	2401	2266	23.6
46.552	934	2717	2730	23.7
100.000	1037	3009	3147	25.3
100.000	1051	3029	3173	21.3

470. B = $C_{13}H_7Cl_3$, Trichlorofluorene (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$	t
0.000	828	2299	2108	11.5
0.000	819	2283	2102	17.6
9.479	822	2299	2116	18.0
9.735	826	2318	2135	11.6
9.906	822	2295	2127	18.5

471. B = $C_{13}H_8Br_2$, 2, 7-Dibromofluorene (76)

0.000	816	2275	2087	22.9
0.000	809	2263		27.2
9.201	827	2312	2131	24.1
9.532	829	2286		26.8
10.776	827	2316	2124	26.0

472. B = $C_{13}H_8O$, Fluorenone (76)

0.000	818	2293	2105	16.7
10.846	845	2361		16.9

473. B = $C_{13}H_{10}$, Fluorene (76)

0.000	818	2293	2105	16.7
9.171	827	2303	2106	16.8

474. B = $C_{13}H_{12}$, Diphenylmethane (76)

0.000	824	2290	2097	15.7
17.968	770	2144	1954	15.6

475. B = $C_{13}H_{12}O$, 1-Methyl-2-acetylnaphthalene (76)

0.000	821	2284	2101	16.5
43.769	843	2390	2281	16.4
100.000	879	2520	2505	16.1

476. B = $C_{13}H_{12}O_2$, Ethyl β-naphthoate (76)

0.000	857	2258	2104	15.6
10.530	870	2239	2081	15.6

477. B = $C_{13}H_{14}$, 1-Methyl-2-ethylnaphthalene (76)

0.000	821	2291	2108	16.0
64.421	747	2118	1943	15.7
100.000	716	2013	1844	15.4

478. B = $C_{14}H_8Br_2$, 9, 10-Dibromoanthracene (76)

0.000	765	2128		99.5
0.000	761	2133		99.6
9.114	820	2326		99.7
9.776	833	2334		99.6

479. B = $C_{14}H_8Cl_2$, 1, 4-Dichloroanthracene (76)

0.000	762	2148		99.0
9.064	822	2303		99.2
9.678	821	2320		99.0

480. B = $C_{14}H_8Cl_2$, 1, 5-Dichloroanthracene (76)

0.000	756	2150		99.3
0.000	760	2144		99.4
8.278	807	2287		99.3
10.255	825	2323		99.4

481. B = $C_{14}H_8Cl_2$, 9, 10-Dichloroanthracene (76)

0.000	756	2144		99.3
0.000	765	2136		99.3
9.828	828	2387		99.2
9.972	834	2386		99.3

482. B = $C_{14}H_8Cl_2$, 9, 10-Dichlorophenanthrene (6)

% B	$\binom{6563}{5876}$	$\binom{5876}{4861}$	t
0.000	864	2212	25.4
5.981	879	2250	25.5
6.644	879	2250	25.6

483. B = $C_{14}H_9Cl$, α-Chloroanthracene (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$	t
0.000	821	2289		17.0
0.000	812	2293	2095	18.9
0.000	756	2137		100.3
11.891	824	2367		99.7
13.780	900	2560	2545	18.8
19.448	938	2685	2752	16.7
100.000	1373	4232		99.5

484. B = $C_{14}H_9Cl$, β-Chloroanthracene (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	t
0.000	766	2138	99.7
9.258	820	2301	99.6
10.346	824	2316	99.7

485. B = $C_{14}H_9Cl$, 9-Chloroanthracene (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$	t
0.000	819	2297	2106	14.1
0.000	817	2298	2106	14.4
11.713	860	2604	2583	14.4
12.214	904	2578	2597	14.1

486. B = $C_{14}H_9Cl$, 9-Chlorophenanthrene (6)

% B	$\binom{6563}{5876}$	$\binom{5876}{4861}$	t
0.000	863	2212	25.6
9.986	886	2281	25.7
10.714	878	2275	25.7
100.000	1093	2892	100.5

487. B = $C_{14}H_{10}$, Anthracene (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	t
0.000	760	2146	99.4
9.822	824	2347	99.5
10.950	829	2366	99.5

488. B = $C_{14}H_{10}$, Phenanthrene (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$	t
0.000	819	2294	2099	15.6
10.653	856	2380	2171	15.7
25.995	896	2509	2335	15.7
100.000	3942	t_α = 130.6°, t_D = 129.6°.		

489. B = $C_{14}H_{10}Br_2$, 2, 7-Dibromo-9-methylfluorene (76)

0.000	825	2291	2106	13.8
10.013	845	2317	2153	13.7
17.244	840	2355	2173	13.8

490. B = $C_{14}H_{12}$, 9, 10-Dihydroanthracene (76)

0.000	818	2288	2101	17.3
13.749	788	2200	2017	17.2
18.578	807	2169	1998	17.0

491. B = $C_{14}H_{12}$, Dihydrophenanthrene (6)

% B	$\binom{6563}{5876}$	$\binom{5876}{4861}$	t
0.000	917	2212	24.6
9.319	886	2290	24.5
9.911	887	2297	24.5

492. B = $C_{14}H_{12}$, Stilbene (6)

0.000	870	2226	20.5
9.673	921	2372	19.9
9.709	929	2366	21.7

493. B = $C_{14}H_{14}O$, 1-Ethyl-4-acetylnaphthalene (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$	t
0.000	825	2287	2101	16.0
39.667	826	2324	2210	16.0
100.000	840	2395	2388	15.7

494. B = $C_{14}H_{15}NO$, α-Acetylethylaminonaphthalene (76)

0.000	817	2283	2105	20.2
12.087	801	2237	2052	20.3
100.000	660	1874		27.3
100.000	632	1779		99.0

495. B = $C_{14}H_{15}NO$, β-Acetylethylaminonaphthalene (76)

0.000	812	2264	2093	24.1
9.873	802	2229	2052	23.5
48.278	751	2105	1874	23.5
100.000	698	1949	1778	23.1

496. B = $C_{14}H_{17}N$, α-Diethylaminonaphthalene (76)

0.000	825	2289	2101	18.0
10.258	821	2273	2109	18.0
44.072	805	2197	1888	18.0
100.000	720	2079	1895	18.1

497. B = $C_{14}H_{17}N$, β-Diethylaminonaphthalene (76)

0.000	813	2273	2100	22.1
10.871	848	2372	2266	21.8
46.652	926	2660	2796	21.9
100.000	991	3006	3379	21.6

498. B = $C_{14}H_{17}N$, 1, 4-Diethylaminonaphthalene (76)

0.000	818	2298	2106	14.2
23.080	794	2249	2140	14.2
100.000	622	1884	1904	99.6

499. B = $C_{14}H_{17}N$, 2, 3-Diethylaminonaphthalene (76)

0.000	814	2281	2097	20.6
10.137	815	2294	2143	20.7
16.494	816	2297	2176	20.8
100.000	736	2192		99.3

500. B = $C_{14}H_{24}N_2$, Tetraethyl-*o*-phenylenediamine (76)

0.000	822	2305		10.7
19.935	748	2103		10.6
100.000	458	1333	1187	12.6

501. B = $C_{14}H_{24}N_2$, Tetraethyl-*m*-phenylenediamine (76)

0.000	822	2304		11.2
13.739	791	2236		10.8
46.892	718	2042		11.0
100.000	589	1684	1538	11.8

502. B = $C_{14}H_{24}N_2$, Tetraethyl-*p*-phenylenediamine (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	t
0.000	822	2305	10.7
14.310	793		10.4
100.000	520	1566	99.3

503. B = $C_{15}H_{10}$, Fluoranthrene (6)

% B	$\binom{6563}{5876}$	$\binom{5876}{4861}$	t
0.000	869	2222	18.6
9.974	925	2414	18.7
0.000	869	2219	15.3
14.023	955	2503	15.2

504. B = $C_{15}H_{11}Cl$, 1-Methyl-4-chloroanthracene (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$	t
0.000	819	2288	2105	17.2
13.007	889	2524	2502	17.2
16.596	917	2582		17.2

505. B = $C_{15}H_{12}$, α-Methylanthracene (76)

0.000	828	2289	2104	14.5
0.000	820	2290	2103	15.6
9.213	871	2488	2411	15.3
16.901	932	2652	2681	14.4
17.059	936	2652	2661	15.1
100.000	1335	4079		99.4

506. B = $C_{15}H_{12}$, β-Methylanthracene (76)

0.000	770	2135		99.1
0.000	765			99.5
8.604	831			99.6
9.409	816	2317		99.3

507. B = $C_{15}H_{12}$, 9-Methylanthracene (76)

0.000	819	2290	2107	14.9
0.000	819	2292	2092	17.0
9.851	890	2538	2525	14.7
10.518	898	2548	2542	16.7
100.000	1423	4486		99.4

508. B = $C_{15}H_{12}O$, Anthranol methyl ether (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	t
0.000	819	2288	17.2
10.801	891	2535	17.2
17.879	936	2701	17.2
100.000	1406	4429	99.3

509. B = $C_{15}H_{14}$, *m*-Methylstilbene (76)

0.000	826	2292	14.5
13.297	884	2479	14.7

510. B = $C_{16}H_{10}$, Pyrene (6)

% B	$\binom{6563}{5876}$	$\binom{5876}{4861}$	t
0.000	878	2221	17.1
13.783	970	2572	17.0
0.000*	869	2222	18.6
9.789*	932	2468	18.8

* A second preparation.

C_9H_7N.—(*Continued*)

511. B = $C_{16}H_{13}Cl$, 9-Ethyl-10-chloroanthracene (76)

% B	$\binom{6563}{5893}$	$\binom{5893}{4861}$	$\binom{4861}{4341}$	t
0.000	826	2301	2100	13.0
0.000	822	2293		14.2
10.527	896	2559		12.6
11.080	900	2576		14.2

512. B = $C_{16}H_{16}O$, Ethylhydroanthranol (76)

0.000	819	2288	2103	16.3
0.000	821	2289		17.0
18.203	771	2129		16.8
24.909	751	2094		16.2

513. B = $C_{17}H_{14}Br_2O_2$, Ethyl 2, 7-dibromofluorene-9-acetate (76)

0.000	822	2296	2111	13.4
16.726	822	2296	2110	13.3
100.000	773	2181	1948	99.8

514. B = $C_{18}H_{18}$, Retene (6)

% B	$\binom{6563}{5876}$	$\binom{5876}{4861}$	t
0.000	870	2223	17.9
10.550	877	2277	17.5
0.000*	864	2211	25.6
11.718*	879	2259	25.6

* A second preparation.

515. B = $C_{20}H_{28}O_2$, 1, 5-Dihydroxynaphthalene diamyl ether (76)

% B	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$	t
0.000	817	2280	2098	22.2
11.097	791	2196	2023	22.3
19.983	762	2140	1958	22.3
100.000	519	1521		99.9

$C_{10}H_6Cl_2$

1, 4-Dichloronaphthalene

516. B = $C_{10}H_{12}$, Tetralin (76)

% A	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$	t
0.000	433	1255	1045	20.2
12.072	487	1339	1161	20.2

517. B = $C_{10}H_{15}N$, Diethylaniline (76)

0.000	588	1614	1494	16.7
12.456	608	1687	1572	16.7

518. B = $C_{12}H_{14}O_4$, Diethyl phthalate (76)

0.000	393	1081	921	17.7
13.994	458	1211	1061	17.6

519. B = $C_{12}H_{16}O_2$, Amyl benzoate (76)

0.000	384	1032	890	17.4
12.770	420	1158	999	18.3

$C_{10}H_8$

Naphthalene

520. B = $C_{10}H_{15}N$, Diethylaniline (76)

% A	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$	t
0.000	567	1634	1500	12.3
10.171	600	1698	1559	12.9
20.922	633	1765		13.2
100.000	746	2110	1933	99.6

521. B = $C_{12}H_{14}O_4$, Diethyl phthalate (76)

0.000	389	1085	896	16.8
11.274	421	1238	1028	17.5
20.912	488	1340	1167	17.5
100.000	746	2110	1933	99.6

$C_{10}H_9N$

α-Naphthylamine

525. B = $C_{10}H_{12}$, Tetralin (76)

% A	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$	t
0.000	443	1248	1054	20.6
10.572	500	1423	1255	20.7

III. Ternary Aqueous Mixtures

541. B = HNO_3; C = $Hg(NO_3)_2$, Anhydrous (Pulfrich) (94)

% C	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0	19#	42#	35#
5.3037	20#	46#	36#
0	19#	41#	37#
6.6201	22#	37#	46#

542. B = HNO_3; C = $Hg_2(NO_3)_2$, Anhydrous (Pulfrich) (94)

% C	$\binom{C}{D}$	$\binom{D}{F}$	$\binom{F}{G'}$
0	20#	42#	34#
4.0118	20#	44#	36#
7.4925	20#	46#	36#
0	19#	42#	35#
7.9896	21#	47#	38#

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ELECTRIC AND MAGNETIC BIREFRINGENCE

H. Mouton

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Introduction.—While a non-crystalline substance is in either an electric or a magnetic field it acts optically as a uniaxial crystal with its axis parallel to the field intensity, Kerr (23), Cotton and Mouton (7, 12). Some act as positive (+) others as negative (−) crystals. Crystalline substances are excluded from this section. The molecules of "crystalline" liquids seem to be completely aligned by the applied field and the order of the resulting birefringence is 10^6 times as great as that of the liquids here considered.

General Relations.—If n = index of refraction of the substance when in zero field, n_e and n_o = indices when in a field of strength E (electric) or H (magnetic), λ = wave-length of the light *in vacuo*, l = actual length of path of the light in the substance and perpendicular to the field, δ = difference in the equivalent optical paths of the components with electric vector parallel and perpendicular, respectively, to the field, then the *coefficients of birefringence* (C_e, C_m) are defined by the equations $\delta/\lambda = (n_e - n_o)l/\lambda = C_e l E^2$ (or $= C_m l H^2$), or $(n_e - n_o) = C_e \lambda E^2$ (or $= C_m \lambda H^2$). C_e and C_m depend upon λ, the temperature (t), and the substance; for any given gas, C_e is proportional to its density (19, 27). C_e is sometimes called Kerr's constant; it should not be confused with Kerr's magneto-optic constant, Vol. VI, p. 435.

Variation with λ.—For any substance at a constant temperature, Havelock (20, 21) concludes that $n(n_e - n_o) = k(n^2 - 1)^2$, or $C_e\lambda n/(n^2 - 1)^2 = k_e$, $C_m\lambda n/(n^2 - 1)^2 = k_m$, where k, k_e, k_m are pure numbers which are independent of λ, *cf.* (30, 31, 37). For anisole (C_7H_8O), phenetole ($C_8H_{10}O$), and *m*-xylene (C_8H_{10}), k_e has been found to be independent of λ; for toluene (C_7H_8) and ethyl *n*-butyrate ($C_6H_{12}O_2$), k_e varies slightly with λ; and for ethyl ether ($C_4H_{10}O$) and acetal ($C_6H_{14}O_2$), $C_e\lambda$ varies less than this relation indicates (4). For a number of substances (37, 40), including nitrobenzene ($C_6H_5NO_2$) (8, 12), k_m has been found to be independent of λ.

Variation with *t*.—For a given λ, Langevin (25) concludes that $C_e nT/\{d(n^2 + 2)^2(\epsilon + 2)^2\} = \varphi_e$ and $C_m nT/\{d(n^2 + 2)^2\} = \varphi_m$, where d = density, ϵ = dielectric constant, and φ_e and φ_m are independent of absolute temperature (T). The constancy of φ_e has been verified for ethyl ether ($C_4H_{10}O$) and for CS_2 from −78.5°C to + 18°C (29), and for nitrobenzene ($C_6H_5NO_2$) from 6.14°C to 25°C and for 5 values of λ (38). The value of φ_m frequently varies non-linearly by several parts in 1000 per 1°C; *cf.* Table 5. In Tables 1, 2, 3, coefficients for linear interpolation over short ranges are given if available.

Time Effects.—The time required for C_e to reach its equilibrium value after the field is applied or removed is approximately proportional to C_e and is of the order of 10^{-8} sec $= 0.01\mu$ sec (1, 2, 3, 5.1, 17, 36); *see* CS_2 (Table 1), and C_7H_8 and $C_{10}H_7Br$ (Table 3). The effect of electrostriction (*see* Vol. VI, p. 207) and the heating produced by the conduction current complicate the determination of $(n_e - n)$ and $(n_o - n)$ in electric birefringence. Both effects are reduced by applying the field quickly and maintaining it for a very short time (τ); *see* following.

Ratio of Changes in Index.—Different theories of electric birefringence predict different values for $\rho \equiv (n_e - n)/(n_o - n)$. That which makes the birefringence (electric or magnetic) depend upon the orientation of the molecules makes $\rho = -2$; Voigt's theory (43) which makes it depend upon a modification of the intraatomic forces makes $\rho = +3$, and a more general form of this theory, Enderle (16), makes ρ vary with λ and approach +3 for frequencies which are small as compared with those characteristic of the electrons. Using very short times (τ) so as to minimize effects of electrostriction (Vol. VI, p. 207) and heating, Pauthenier (35) found for nitrobenzene ($C_6H_5NO_2$) and $\tau = 0.46$, 0.92, 1.6, and 2.7μ sec ($=10^{-6}$ sec), $\rho = -2.01$, −1.99, −2.03, and −2.04, respectively; the same was found for red, yellow-green and blue light; Himstedt (22) found $\rho = -1.92$; McComb (31), $\rho = -1.88$ for $0.540\mu < \lambda < 0.660\mu$. For CS_2, electrostriction compensates the change in $(n_o - n)$, making the apparent (ρ') value of ρ infinite, when $\tau = 8.1\mu$ sec. If electrostriction alone increases the index from n to $n + \delta'$, and we write $\beta \equiv \delta'(n_o - n)$, then $\rho' = (\beta + 2)/(\beta - 1)$; for CS_2, Pauthenier (35) found as follows:

τ	0.65	1.3	2.5	4.9	7	8.1	9.8
β	0	0	0.12	0.36	0.74	1	1.4

τ	20	25	30.7	41.7	49	65.6μ sec
β	2	1.47	1	1.3	1.1	1.1

Relation between Electric and Magnetic Birefringence.—The preceding temperature relations indicate that $C_e/\{C_m(\epsilon + 2)^2\} = \varphi_e/\varphi_m$ is independent of T. Cotton and Mouton (12) have proposed the simpler relation $C_e/(C_m\epsilon) = $ const., and have found it more satisfactory for nitrobenzene ($C_6H_5NO_2$); their values are as follows, a and b being arbitrary constants:

t	aC_e	bC_m	ϵ	$\frac{a}{b} \cdot \frac{C_e(10)^4}{\epsilon C_m}$	$\left(\frac{C}{C_{16°}}\right)_e$	$\left(\frac{C}{C_{16°}}\right)_m$
6°C	68	129	39.4	133.9	1.18	1.08
16	57.6	119.5	37.4	129.0	1.00	1.00
33	45.8	105.2	34.2	127.4	0.79_6	0.88_1
54	37.2	90.8	30.6	133.9	0.64_6	0.76_0

Units.—Unit of $\lambda = 1\mu = 10^4$ Å $= 10^{-4}$ cm.

TABLE 1.—ELECTRIC BIREFRINGENCE OF CS_2 (6, 18, 29, 30)

$n_e - n_o = C_e\lambda E^2$. $A \times 10^{-7} = C_e$ when λ is expressed in cm and E in cgs electrostatic units. Time required for A_{20} to attain equilibrium value is 0.014μ sec $= 14 \times 10^{-9}$ sec (17). $A_{15} = 1.025\ A_{20}$, $A_{28} = 0.966\ A_{20}$; approximately $A_t = A_{20}\ [1 - 0.005\ (t - 20)]$ if $18° < t < 28°$C (26, 27); for lower temperatures, *see* below. For effect of electrostriction, *see* above.

λ	A	$A\lambda$	t'	$A_{t'}/A_{18°}$
	(t = 20°C)			(29)
0.589	+3.226* ±0.005		+18°C	1.000
0.440	+4.97	2.187	0	1.089
0.460	+4.63	2.130	−18.5	1.205
0.480	+4.32	2.073	−37.7	1.397
0.500	+4.06	2.030	−47.3	1.497
0.520	+3.83	1.991	−68.3	1.708
0.540	+3.63	1.960	−78.5	1.819
0.546	+3.577†	1.953		
0.560	+3.45	1.932		
0.578	+3.310†	1.913		
0.580	+3.30	1.914		
0.589	+3.226†	1.900		
0.600	+3.15	1.890		
0.630	+2.95	1.858		
0.660	+2.78	1.835		

* Basis of reference (6).

† (6).

TABLE 2.—MAGNETIC BIREFRINGENCE OF NITROBENZENE (C_6H_5-NO_2) (9, 12)

$(n_e - n)/(n_o - n) = -2.00$, $k_m \equiv C_m\lambda n/(n^2 - 1)^2 = 1.11 \times 10^{-16}$ at 19 to 20°C, is independent of λ. $\varphi_m = C_m nT/\{d(n^2 + 2)^2\}$ varies non-linearly with T; $C_e/C_m\epsilon$ is nearly independent of t. $C_{mt} = C_{m_{20}}\ [1 - \alpha(t - 20)]$; if $10°\text{C} < t < 25°\text{C}$, $\alpha = 1/135$; near 20°C, $\alpha = 1/144$; mean variation per 1°C. between 6.4°C and 53.9°C is 1/138 of mean value of C_m (8, 12). $n_e - n_o = C_m\lambda H^2$; $A \times 10^{-12} = C_m$, if λ is expressed in cm and H in cgsm (gauss). t = 20°C; $1\mu = 10^{-4}$ cm.

λ	0.578	0.436	0.486	0.546	0.578	0.656
A	2.46 ±0.02*	3.62	3.10	2.66	2.46	2.14
$A\lambda$		1.580	1.509	1.450	1.422	1.405

* Basis of reference; derived from A = 2.53 ± 0.02 at 16.3°C (9).

TABLE 3.—ELECTRIC AND MAGNETIC BIREFRINGENCE OF PURE SUBSTANCES: RELATIVE VALUES

For most inorganic liquids C_e and C_m are inappreciable, but magnetic birefringence should be exhibited by those paramagnetic substances which have quite anisotropic molecules (*cf.* aqueous solution of erbium nitrate, Table 4). For organic substances containing only C, H and O, C_m is very small or zero if they are acyclic, and, so far as they have been studied, it is inappreciable if they contain a cyclic nucleus without a double bond.

In this table $\gamma_e/100 \equiv (C/C_{CS_2})_e$, where C and C_{CS_2} refer to the same temperature (20°C) and the same radiation (usually D-line, $\lambda = 0.589\mu$), and $\gamma_m/100 \equiv (C/C_{C_6H_5NO_2})_m$ where $C_6H_5NO_2$ = nitrobenzene, C and $C_{C_6H_5NO_2}$ refer to the same temperature (t_m) and to the yellow mercury line ($\lambda = 0.578\mu$). For most substances γ_e is nearly independent of λ; as a first approximation, γ_m is independent of t_m. Available data for variation of C_e and γ_e with t and λ are given in footnotes; for variation of C_m and γ_m, *see* Table 5. For $C_e(CS_2)$ and $C_m(C_6H_5NO_2)$, *see* Tables 1 and 2.

Data for γ_e are from (26) unless another source is indicated in a footnote: those for γ_m are from (9, 12). g = gas at 20°C and 1 atm., l = liquid, b. = boils at, m. = melts at.

Pure inorganic substances

Formula		γ_e	γ_m	t, °C	Lit.
H_2O	l	123		17	(35)
SO_2	g	0.051		17.3	(38, 41)
HNO_3	l		+2.5	15.5	(9, 12)
NH_3	g	0.0185		20	(26, 27)
	g	0.0181		17.9	(38, 41)
CO_2	g	0.007		20	(26, 27)
	g	0.0074		17.5	(38, 41)

Glasses (Schott and Gen.) (42), t = 20°C

Number	γ_e	% PbO	% SiO_2	Number	γ_e	% PbO	% SiO_2
O378	0.288	27.5	59.3	O41	2.950	61.0	34.7
O569	1.096	36.3	54.1	O165	3.277	65.5	31.2
O118	1.845	43.8	46.6	O198	3.951	71.0	27.2

Carbon compounds (ℭ-arrangement)

Formula	Substance	γ_e	γ_m	t_m
CCl_4	Carbon tetrachloride	+ 2.3	0	14.6
CCl_3NO_2	Chloropicrin	− 55.7	+ 3.4	14.2
CN_4O_8	Tetranitromethane	+ 3	+ 1.0	14.2
CS_2	Carbon disulfide	+ 100.00*	− 19.6	15.5
$CHBr_3$	Bromoform	− 86	− 6.8	14.6
$CHCl_3$	Chloroform	− 100	− 2.8	17.2
CHN	Hydrocyanic acid (g)	+ 0.55		
CH_2Cl_2	Methylene chloride	− 36		
CH_2I_2	Methylene iodide		− 12.3	16
CH_3Br	Methyl bromide (g)	+ 0.216		
CH_3Cl	Methyl chloride (g)	+ 0.163		
CH_3I	Methyl iodide	+ 208†	− 2.9	14
CH_3NO_2	Nitromethane	+ 330	+ 3.6	18.4
C_2Cl_4	Tetrachloroethylene	+ 24		
C_2HCl_3	Trichloroethylene	+ 43		
C_2HCl_5	Pentachloroethane	− 20		
$C_2H_2Br_4$	1, 1, 2, 2-Tetrabromoethane	− 103		
$C_2H_2Cl_2$	1, 2-Acetylene dichloride	+ 40		
$C_2H_2Cl_4$	1, 1, 2, 2-Tetrachloroethane	− 88.7	− 1.3	16
$C_2H_3Cl_3$	1, 1, 2-Trichloroethane	+ 50		
$C_2H_4Br_2$	Ethylene bromide	+ 89	− 7.1	16.4
$C_2H_4Cl_2$	Ethylene chloride	+ 181	− 2.1	14
$C_2H_4Cl_2$	1, 1-Dichloroethane		− 1.8	14
$C_2H_4O_2$	Acetic acid (17°)	+ 130‡		
C_2H_5Cl	Ethyl chloride (g)	+ 0.270		
C_2H_5I	Ethyl iodide	+ 343		
C_2H_6O	Ethyl alcohol	+ 23.8‡	+ 0	14.6
C_3H_5Cl	3-Chloropropylene	+ 174		
C_3H_5ClO	Epichlorohydrin	+ 185		
$C_3H_5ClO_2$	Ethyl chloroformate	+ 354		
C_3H_5NS	Ethyl isothiocyanate		− 8.4	14.6
C_3H_6O	Acetone	+ 505	+ 1.6	20.2

TABLE 3.—(*Continued*)

Formula	Substance	γ_e	γ_m	t_m
$C_3H_6O_2$	Propionic acid	+ 44		
$C_3H_6O_2$	Ethyl formate	+ 138		
C_3H_7Br	*n*-Propyl bromide	+ 318		
C_3H_7Cl	*n*-Propyl chloride	+ 234		
C_3H_8O	*n*-Propyl alcohol	− 78		
$C_3H_8O_2$	Methylal	+ 0.3		
C_4H_4S	Thiophene		+ 15.6	14.8
$C_4H_5Br_3O_2$	Ethyl tribromoacetate		− 2.2	16
$C_4H_5Cl_3O_2$	Ethyl trichloroacetate	+ 161		
C_4H_5N	Pyrrole	+ 12§	+ 7 *ca.*	16
C_4H_8O	Methyl ethyl ketone	+ 420		
$C_4H_8O_2$	Isobutyric acid	+ 6		
$C_4H_8O_2$	Ethyl acetate	+ 52		
C_4H_9Br	Isobutyl bromide	+ 271.5		
$C_4H_{10}O$	*n*-Butyl alcohol	− 113		
$C_4H_{10}O$	Isobutyl alcohol	− 137		
$C_4H_{10}O$	*tert.*-Butyl alcohol	+ 154		
$C_4H_{10}O$	Ethyl ether	− 20.5‖		
$C_4H_{10}S$	Ethyl sulfide	+ 10.6		
$C_4H_{10}S_2$	Ethyl disulfide	− 168		
$C_4H_{11}N$	Diethylamine	− 15.3		
$C_5H_4O_2$	Furfural		+ 45 *ca.*	17
C_5H_5N	Pyridine	+ 632	+ 27 *ca.*	18.5
C_5H_6	Cyclopentadiene	+ 14.1	(b. 40 to 43°C)	
$C_5H_7NO_2$	Ethyl cyanoacetate	+ 1 200	+ 0	14.6
C_5H_8	Isoprene		2.7	16.3
$C_5H_8O_2$	Acetylacetone		+ 4.2	16.3
C_5H_{10}	Amylene	+ 8	(b. 36 to 37°C)	
$C_5H_{10}O_2$	*n*-Valeric acid	+ 8.4		
$C_5H_{10}O_2$	Methyl *n*-butyrate	+ 24		
$C_5H_{10}O_3$	Diethyl carbonate	+ 9.6		
$C_5H_{11}Cl$	Isoamyl chloride	+ 108		
$C_5H_{11}Cl$	*tert.*-Amyl chloride	+ 345		
C_5H_{12}	*n*-Pentane	+ 2.0		
C_5H_{12}	2-Methylbutane	+ 1.6		
$C_5H_{12}O$	*n*-Amyl alcohol¶	− 98		
$C_5H_{12}O$	*tert.*-Amyl alcohol	+ 40		
$C_5H_{13}N$	Isoamylamine	− 0.3		
$C_6H_3ClN_2O_4$	2, 4-Dinitrochlorobenzene	(Fused)	108	(?)
$C_6H_3N_3O_7$	2, 4, 6-Trinitrophenol	+ 45		
$C_6H_4Cl_2$	*o*-Dichlorobenzene	+ 1 320§		
$C_6H_4Cl_2$	*m*-Dichlorobenzene	+ 218§		
C_6H_5Br	Bromobenzene	+ 374	+ 25.7	15.7
C_6H_5Cl	Chlorobenzene	+ 385	+ 28.8	20
C_6H_5ClO	*o*-Chlorophenol	+ 189		
$C_6H_5ClO_2S$	Benzenesulfone chloride	+ 2 775		
C_6H_5F	Fluorobenzene	+ 191**	+ 25.5	13
C_6H_5I	Iodobenzene	+ 288	+ 24.8	16.4
$C_6H_5NO_2$	Nitrobenzene (21.3°)	+10 070††	+100.0††	13.4
C_6H_6	Benzene	+ 12	+ 23.3	18.3
C_6H_7N	Aniline	− 50.7§	+ 16.0	13.4
$C_6H_8N_2$	Phenylhydrazine‡‡	+ 0	+ 29.6	20.4
$C_6H_{10}O_3$	Ethyl acetoacetate	+ 145		
$C_6H_{11}NO_2$	Ethyl β-aminocrotonate	+ 960		
C_6H_{12}	Cyclohexane	+ 2.2	+ 0	
$C_6H_{12}O$	Cyclohexanol	− 286		
$C_6H_{12}O_2$	Caproic acid	+ 8.7		
$C_6H_{12}O_2$	Ethyl *n*-butyrate	+ 21§§		
$C_6H_{12}O_3$	Paraldehyde	− 713	+ 0	
C_6H_{14}	*n*-Hexane	+ 1.7		
$C_6H_{14}O_2$	Acetal	− 19‖‖		
$C_7H_4F_3NO_2$	*p*-Nitrophenylfluoroform		+ 58.0	15
C_7H_5ClO	Benzoyl chloride		+ 66	13.6
$C_7H_5Cl_3$	Phenylchloroform		+ 25.4	17
$C_7H_5F_3$	Phenylfluoroform		+ 26.7	16.8
C_7H_5N	Benzonitrile		+ 39.5	14
	Benzonitrile ($\lambda = 0.550\mu$)		+ 36.2	20.2
$C_7H_6Cl_2$	Benzylidene chloride	+ 318	+ 23.8	16.6
C_7H_6O	Benzaldehyde	+ 2 496	+ 59.5	15.2
C_7H_7Cl	*o*-Chlorotoluene	+ 270¶¶		
C_7H_7Cl	*p*-Chlorotoluene	+ 711¶¶		
C_7H_7Cl	Benzyl chloride		+ 24.2	16.6
C_7H_7NO	Benzaldoxime‡‡		+ 67.6	12.5
$C_7H_7NO_2$	*o*-Nitrotoluene	+ 5 400	+ 58 *ca.*	16.5
$C_7H_7NO_2$	*m*-Nitrotoluene	+ 5 500	+ 77 *ca.*	22
$C_7H_7NO_2$	*p*-Nitrotoluene‡‡	+ 6 900		
C_7H_8	Toluene	+ 24***	+ 24.5	17.5
C_7H_8O	Benzyl alcohol	− 477	+ 26.0	15.8

TABLE 3.—(*Continued*)

Formula	Substance	γ_e	γ_m	t_m
C_7H_8O	*m*-Cresol	+ 657		
C_7H_8O	Phenyl methyl ether†††	+ 35.5	+ 22.2	16.5
C_7H_9N	*o*-Toluidine	− 73		
C_7H_9N	*m*-Toluidine	− 128		
$C_7H_{12}O_4$	Diethyl malonate	+ 48		
C_7H_{14}	Methylcyclohexane	+ 2		
$C_7H_{14}O$	Heptaldehyde	+ 125		
$C_7H_{14}O$	Dipropyl ketone	+ 157		
$C_7H_{14}O$	1-Methylcyclohexanol	− 172		
	2-Methylcyclohexanol	− 163		
	3-Methylcyclohexanol	− 319		
$C_7H_{14}O_2$	Heptylic acid	+ 8.2		
$C_7H_{14}O_2$	*n*-Amyl acetate	+ 38		
$C_7H_{14}O_2$	Ethyl *n*-valerate	+ 10		
C_7H_{16}	*n*-Heptane	+ 3.3		
$C_7H_{16}O$	*n*-Heptyl alcohol	− 233		
C_8H_6	Phenylacetylene		+ 27.5	14.1
C_8H_7ClO	*m*-Chloroacetophenone	+ 2 140		
C_8H_7N	Benzyl cyanide		+ 22.5	14.2
C_8H_8	Styrene (redistilled)		+ 36.8	15.2
C_8H_8O	Acetophenone‡‡	+ 2 060	+ 49	21.7
$C_8H_8O_2$	Methyl benzoate		+ 40.3	14.8
C_8H_9ClO	*p*-Chlorophenetole		+ 26.4	15.1
C_8H_9FO	*p*-Fluorophenetole		+ 30.8	17.8
C_8H_9N	Benzylidenemethylamine		+ 45.8	13.6
C_8H_{10}	*o*-Xylene	+ 41	+ 27.8	14
C_8H_{10}	*m*-Xylene‡‡‡	+ 24	+ 25.0	16.2
C_8H_{10}	*p*-Xylene	+ 23	+ 26.6	20
C_8H_{10}	Ethylbenzene	+ 25.6	+ 21.5	17.4
$C_8H_{10}O$	Phenylethyl alcohol		+ 19.0	13.8
$C_8H_{10}O$	Phenetole‡‡‡	+ 41	+ 21.8	14.8
$C_8H_{11}N$	Dimethylaniline	+ 312		
$C_8H_{14}O_3$	Ethyl dimethylacetoacetate	+ 137.5		
C_8H_{16}	*n*-Octylene	+ 13	(b. 116 to 126°C)	
C_8H_{16}	1, 3-Dimethylcyclohexane	+ 3		
$C_8H_{16}O_2$	*n*-Caprylic acid	+ 9.4		
C_8H_{18}	*n*-Octane	+ 4.2	(b. 110 to 125°C)	
$C_8H_{18}O$	*n*-Octyl alcohol	− 236		
C_9H_7N	Quinoline	+ 466§	+ 83.0	14.9
C_9H_8	Indene		+ 44.6	13.8
C_9H_{10}	Hydrindene		+ 28.4	15.2
$C_9H_{10}O$	Hydratropaldehyde	+ 314		
$C_9H_{10}O_2$	Benzyl acetate		+ 33 *ca.*	(?)
$C_9H_{10}O_2$	Ethyl benzoate		+ 37	16
$C_9H_{10}O_3$	Ethyl salicylate	+ 607		
$C_9H_{11}N$	*Py*-Tetrahydroquinoline		+ 36.5	16.8
C_9H_{12}	Cumene	+ 102§§§	+ 26.0	14.5
C_9H_{12}	Mesitylene	+ 19	+ 22.2	16
C_9H_{12}	*n*-Propylbenzene		+ 20.3	18.3
C_9H_{12}	Pseudocumene	+ 30	+ 28.0	15.6
$C_9H_{18}O_2$	Pelargonic acid	+ 8.3		
$C_{10}H_7Br$	α-Bromonaphthalene‖‖‖	+ 332	+ 99	17
$C_{10}H_7Cl$	α-Chloronaphthalene		+108	15
$C_{10}H_9N$	α-Methylquinoline	+ 25.6	+ 93.6	16.5
$C_{10}H_{10}$	Phenylbutadiene		+ 64	15.4
$C_{10}H_{10}O_2$	Safrol		+ 24.1	17.2
$C_{10}H_{10}O_2$	Isosafrol		+ 49.5	17.2
$C_{10}H_{12}O$	Anethole		+ 74.1	21.4
$C_{10}H_{12}O_2$	Eugenol		+ 20.9	15.8
$C_{10}H_{12}O_2$	Isoeugenol		+ 36.0	16.8
$C_{10}H_{12}O_2$	*n*-Propyl benzoate		+ 33	13.4
$C_{10}H_{14}O$	Carvacrol	+ 83	+ 15.1	13
$C_{10}H_{14}O$	Carvone	+ 730¶¶¶		
$C_{10}H_{14}O$	Thymol‡‡		+ 17.7	13.4
$C_{10}H_{15}N$	Diethylaniline	+ 323		
$C_{10}H_{16}$	Limonene	+ 18¶¶¶	($d_{18} = 0.845$ g cm^{-3})	
$C_{10}H_{16}O$	Camphor	+ 159¶¶¶		
$C_{10}H_{18}$	Dihydropinene		+ 0	
$C_{10}H_{18}$	Dihydrolimonene		+ 0	
$C_{10}H_{18}O$	Cineol		+ 0	
$C_{10}H_{22}$	Diisoamyl	+ 2.2		
$C_{10}H_{23}N$	Diamylamine	− 6.05		
$C_{11}H_7N$	α-Naphthyl cyanide‡‡		+166	17
$C_{11}H_{10}$	α-Methylnaphthalene	+ 66		
$C_{11}H_{12}O_2$	Ethyl cinnamate	+ 228	+ 60 *ca.*	17
$C_{11}H_{12}O_3$	Ethyl benzoylacetate	+ 495		
$C_{11}H_{24}O_2$	Methyl diamyl ether	+ 0		

TABLE 3.—(*Continued*)

Formula	Substance	γ_e	γ_m	t_m
$C_{12}H_{16}O_2$	Amyl benzoate		+ 27 *ca.*	19.7
$C_{13}H_{10}O$	Benzophenone‡‡		+ 57.2	14
$C_{13}H_{10}O_3$	Salol‡‡ (m. 41.5°C)		+ 62****	16
$C_{13}H_{16}O_3$	Ethyl benzylacetoacetate	− 68		
$C_{14}H_{12}$	1, 1-Diphenylethylene		+ 48	16.4
$C_{14}H_{12}O_2$	Benzyl benzoate		+ 38.4	15.8
$C_{14}H_{18}O_4$	Diethyl benzylmalonate	− 48		
$C_{17}H_{12}O_3$	Naphthyl salicylate‡‡		+160	18
$C_{18}H_{34}O_2$	Oleic acid		+ 0	14.6
	Petroleum ether††††		+ 0	15.5

* *See* Table 1.

† $\gamma_e = 207$ to 210

‡ From (35).

§ From (28).

‖ For $\lambda = 0.589\mu$ and 20°C, $C_e = -0.621 \times 10^{-7}$ and $\gamma_e = -19.2$ (41). $C_e\lambda$ varies with λ less rapidly than is indicated by Havelock's relation (p. 109) (4); variation with t satisfies Langevin's relation (p. 109) from −78.5° to + 18°C, giving (29):

t	18	0	−21.7	−38.9	−60.5	−78.5°C
$C_{et}/C_{e_{18}°}$	1.000	1.220	1.547	1.927	2.707	3.880

¶ Free of pyridine (C_5H_5N).

** $\gamma_e = 184$ to 191.

†† $\gamma_e/100 = 100.7$ at 21.3°, 99.5 at 22.5°, 65.7 at 49°C. Lippmann (28) gives $\gamma_e = 11\,390$ at room temperature. Near 20°C, $C_{et} = C_{e_{20}°}\,\{1 - \frac{1}{68}(t - 20)\}$, and mean change per 1°C between 0 and 47°C is $\frac{1}{68}$ of mean value of C_e (12, 13); between 6.14 and 25°C, change of C_e with t satisfies Langevin's relation (p. 109) (38); $(n_e - n)/(n_o - n) = -2.00$ (p. 109) (22, 30, 31, 35). For C_m and its variation with λ and t, *see* Table 2.

‡‡ Undercooled.

§§ Slight departure from Havelock's relation (p. 109).

‖‖ Variation of $C_e\lambda$ with λ is less than that indicated by Havelock's relation (p. 109).

¶¶ For o-C_7H_7Cl, $\gamma_e = 261$ to 270; for p-C_7H_7Cl, $\gamma_e = 690$ to 711 (28).

*** Slight departure from Havelock's relation (p. 109). Time for C_e to reach equilibrium = 0.017μ sec = 17×10^{-9} sec (17).

††† Phenyl methyl ether = anisole; Havelock's relation for C_e is satisfied (p. 109).

‡‡‡ Havelock's relation for C_e is satisfied (p. 109).

§§§ Boils at 160 to 178°C.

‖‖‖ Time for C_e to reach equilibrium = 0.006μ sec = 6×10^{-9} sec (17). Mean decrease of C_m per 1°C increase between 11.8 and 47.9°C = $\frac{1}{308}$ of mean value of C_m (8, 9, 10, 11, 12, 13).

¶¶¶ Obtained from solution in hexane (C_6H_{14}) using $\lambda = 0.546\mu$ (Hg); value computed for camphor is independent of concentration; electric birefringence and rotary power are superposed without change in either (32).

**** Between −17 and +50.5°C, C_m varies sensibly linearly and $C_{m_t} = C_{m_{20}°}\{1 - \frac{1}{480}(t - 20)\}$ (8, 9, 10, 11, 12, 13).

†††† Mixture of saturated hydrocarbons.

TABLE 4.—ELECTRIC AND MAGNETIC BIREFRINGENCE OF SOLUTIONS AND MIXTURES

(Values of γ_e for limonene ($C_{10}H_{16}$), camphor ($C_{10}H_{16}O$), and carvenone ($C_{10}H_{16}O$) as deduced from solutions in n-hexane (C_6H_{14}) are given in Table 3.)

$\gamma_e/100 = (C/C_{CS_2})_e$, $\gamma_m/100 = (C/C_{C_6H_5NO_2})_m$; $C_6H_5NO_2$ = nitrobenzene. Generally γ can not be readily computed from the composition (Comp.) of the mixture or solution. If γ_e for one constituent of a binary mixture is very great the curve γ_e *vs.* Comp. is usually convex towards axis of Comp.; if γ_e for one is negative and not too nearly zero, the curve is concave towards this axis, and may pass through a maximum at an intermediate Comp.

TABLE 4.—(*Continued*)

Mol % = molecular per cent, Vol. % = volume % = $100\,d'/d$, where d' = mass of constituent in unit volume of mixture, and d = density of same constituent when pure. ⋗ = very much greater than.

H_2O

C_2H_6O, Ethyl alcohol (35)

t = 17°C

Vol. % B	γ_e
0	123
24.2	94
46.3	69.1
66.3	45.4
85.5	26.8
93.5	20.7
96.7	20.0
100	23.8

$Er(NO_3)_3.5H_2O$, Erbium nitrate (14, 15). $\lambda = 0.503\mu$; t = *ca.* 18(?)°C. For H = 26.3 kilogauss and Comp. equivalent to 0.56 g Er_2O_3 per cm³, $\gamma_m = 800$.

$C_6H_5NO_2$

Nitrobenzene (11)

t = *ca.* 18°C

CCl_4, Carbon tetrachloride

Vol % A	γ_m
0	0
19.9	9.8
39.8	23.8
59.6	42.1
79.0	65.6
100	100.0

$C_2H_4Br_2$, 1, 1-Dibromoethane

0	Small
x	$<x$
100	100.0

C_2H_6O, Ethyl alcohol

0	0
51.4	37.4
100	100.0

C_3H_6O, Acetone

0	1.6
x	$<x$
100	100.0

C_6H_6, Benzene; *see* Benzene

C_6H_6

Benzene (28)

t = room temperature

CCl_4, Carbon tetrachloride

Mol % B	γ_e
0	11.3
2.54	11.0
10.99	10.4
64.51	5.3
100	2.3

CH_2Cl_2, Methylene chloride

0	+11.3
7.19	+ 8.8
9.30	+ 8.3
12.78	+ 3.7
100	−36

$C_2H_2Br_4$, 1, 1, 2, 2-Tetrabromoethane

0	+ 11.3
1.98	+ 9.9
8.36	+ 3.6
100	−102.9

$C_2H_4Cl_2$, Ethylene chloride

0	11.3
2.01	11.0
5.10	11.2
15.21	14.0
28.57	22.1
45.2	37.7
100	181

$C_6H_4Cl_2$, o-Dichlorobenzene

0	11.3
2.75	29.9
5.61	49.6
11.74	96
26.47	224
55.23	546.4
100	1 320

$C_6H_4Cl_2$, m-Dichlorobenzene

0	11.3
2.75	13.5
4.53	15.3
11.72	24.3
27.28	47.4
48.15	83.3
100	218.4

$C_6H_5NO_2$, Nitrobenzene

Mol % B	γ_e
0	11.3
2.77	73.6
5.20	131
10.32	288
14.2	401
49.13	2 185
100	11 390

C_6H_7N, Aniline

0	+11.3
4.31	+12.6
13.20	+14.0
17.52	+13.9
36.13	+ 9.6
100	−50.7

$C_7H_7NO_2$, m-Nitrotoluene

0	11.3
3.12	96
9.54	279
19.5	635
36.3	1 363
100	5 664

C_7H_9N, m-Toluidine

0	+ 11.3
4.32	+ 10.3
7.50	+ 9.3
100	−128

C_9H_7N, Quinoline

0	11.3
1.58	13.9
3.49	17.8
13.30	44.3
38.08	133.5
100	466

$C_{10}H_7Br$

α-Bromonaphthalene (11)

t = *ca.* 18°C

CCl_4, Carbon tetrachloride

Vol. % A	γ_m
0	0
x	$\gg 3.32x$
100	332

C_6H_{12}, Cyclohexane

0	0
x	$\gg 3.32x$
100	332

TABLE 5.—MAGNETIC BIREFRINGENCE: VARIATION WITH TEMPERATURE AND WAVE-LENGTH

α_m = mean temperature coefficient of C_{mt} between t' and t''; $\Delta/100 \equiv (\varphi_{mt} - \varphi_{m_{20}})/\varphi_{m_{20}}$ where $\varphi_{mt} \equiv C_{mt}nT/\{d(n^2 + 2)^2\}$, T = absolute temperature corresponding to t. $k_m \equiv C_m\lambda n/(n^2 - 1)^2$; $C_m \equiv (n_e - n_o)/(\lambda H^2)$. If λ is expressed in cm, $C_m = A \times 10^{-12}$, $k_m = B \times 10^{-17}$. $\gamma_m/100 \doteq (C/C_{C_6H_5NO_2})_m$, t and λ same for each C. C_{550}, γ_{550}, etc. = value for $\lambda = 0.550\mu$, etc.

Variation with Temperature (39)

Formula	Substance	α_m	t', °C	t'', °C	Δ_t'	Δ_t''
C_6H_5Br	Bromobenzene	$\frac{1}{444}$	4.7	54.7	5.2	−6.6
C_6H_5Cl	Chlorobenzene	$\frac{1}{139}$	5.2	55.1	5.7	−7.4
$C_6H_5NO_2$	Nitrobenzene	$\frac{1}{136}$	5.4	56.3	6.7	−7.9
	Nitrobenzene (9, 12)	$\frac{1}{135}$*	10	25		
	Nitrobenzene (12)	$\frac{1}{144}$	20	20		
	Nitrobenzene (12)	$\frac{1}{138}$	6.4	53.9		
C_9H_{12}	Pseudocumene	$\frac{1}{143}$	5.1	54.5	4.0	−4.8
$C_{10}H_7Br$	α-Bromonaphthalene	$\frac{1}{218}$	5.7	52.4	0.4	−0.8
	α-Bromonaphthalene (12)	$\frac{1}{303}$	11.8	47.9		
$C_{13}H_{10}O_3$	Salol (12) (m. 41.5°C)	$\frac{1}{480}$†	−17	50.5		

Variation with Wave-length (40), H = 10.11 kilogauss

Formula	Substance	t, °C	B	A_{550}	A_{589}	γ_{550}	γ_{589}
C_6H_5Br	Bromobenzene	20.2	3.29	8.01	7.27	30.5	30.6
C_6H_5Cl	Chlorobenzene	19.8	4.14	8.79	8.14	33.4	33.6
$C_6H_5NO_2$	Nitrobenzene					100.0	100.0
C_7H_5N	Benzonitrile	20.2	4.37	9.60	8.66	36.2	36.3
C_7H_5ClO	Benzoyl chloride	19.9	2.27	19.5	15.9	66.0	66.3
C_7H_8	Toluene	19.4	3.85	7.23	6.71	27.7	28.0
C_7H_8O	Benzyl alcohol	20.2	2.79	6.31	5.91	24.0	24.3
C_8H_{10}	*m*-Xylene	20.2	3.61	6.99	6.33	26.2	26.4
C_8H_{10}	*p*-Xylene	19.7	3.73	7.03	6.53	26.8	27.2
C_9H_7N	Quinoline	19.7	6.85	21.1	19.5	81.1	81.2
$C_{10}H_{12}O$	Anethole	19.1	7.81	19.2	17.4	72.7	72.5

* Of $C_{m_{20°}}$.

† Of $C_{m_{20°}}$; variation is sensibly linear, $C_{mt} = C_{m_{20°}}\{1 - \frac{1}{480}(t - 20)\}$.

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CHEMICAL KINETICS[1]

ANTON SKRABAL

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THEORIES OF REACTION RATE

Reaction rate as a function of temperature and nature of the medium. Applications of statistical mechanics, theories of radiation (quantum theory) and activation theories.

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GENERAL INTRODUCTION

Isothermal Monomolecular First-Order Reactions: A ⟶.

$$\frac{dx}{dt} = k(a - x) \text{ or } -\frac{dC}{dt} = kC \tag{I}$$

Integration gives:

$$k = \frac{1}{t}\log_e \frac{a}{a - x} \text{ or } k = \frac{1}{t}\log_e \frac{C_0}{C} \tag{II}$$

and

$$k = \frac{1}{t_2 - t_1}\log_e \frac{a - x_1}{a - x_2} \text{ or } k = \frac{1}{t_2 - t_1}\log_e \frac{C_1}{C_2} \tag{III}$$

If $\log_{10}$ is used instead of $\log_e$, the constant will become $k' = 0.4343k$; a or C_0 = the initial concentration of the reacting substance and $(a - x_n)$, or C_n, its concentration at a time t_n units later.

Reversible First-Order Reactions.

$$A \underset{k_2}{\overset{k_1}{\rightleftarrows}} B$$

$$\frac{dx}{dt} = k_1(a - x) - k_2(b + x) \tag{IV}$$

$$k_1 + k_2 = \frac{1}{t}\log_e \frac{x_\infty}{x_\infty - x} \text{ or } = \frac{1}{t_2 - t_1}\log_e \frac{x_\infty - x_1}{x_\infty - x_2} \tag{V}$$

where

$$x_\infty = x \text{ for } t = \infty, \backsimeq x \text{ at equilibrium,}$$

where

$$\frac{b + x_\infty}{a - x_\infty} = \frac{k_1}{k_2} = K_E, \text{ the ``equilibrium constant''} \tag{VI}$$

If π be any property of the reacting mixture such that

$$\pi = p(a - x) + q(b + x), \tag{VII}$$

where p and q are proportionality factors, then

$$k_1 + k_2 = \frac{1}{t}\log_e \frac{\pi_0 - \pi_\infty}{\pi - \pi_\infty} \text{ or } = \frac{1}{t_2 - t_1}\log_e \frac{\pi_1 - \pi_\infty}{\pi_2 - \pi_\infty}, \tag{VIII}$$

where the subscript identifies the time to which the π value belongs.

If A and B are optical antipodes,

$$k_1 = k_2 = k,\ k_1 + k_2 = 2k, \text{ and } K_E = 1 \tag{IX}$$

Isothermal Bimolecular Second-Order Reactions: A + B ⟶.

$$\frac{dx}{dt} = k(a - x)(b - x) \tag{X}$$

$$k = \frac{1}{t(b - a)}\left(\log_e \frac{a}{a - x} - \log_e \frac{b}{b - x}\right)$$

or

$$k = \frac{1}{(t_2 - t_1)(b - a)}\left(\log_e \frac{a - x_1}{a - x_2} - \log_e \frac{b - x_1}{b - x_2}\right) \tag{XI}$$

or if b = a

$$k = \frac{1}{ta}\frac{x}{a - x} \text{ or } = \frac{1}{t_2 - t_1}\left(\frac{1}{a - x_2} - \frac{1}{a - x_1}\right) \tag{XII}$$

If a differs but slightly from b, a series expansion of Eq. (XI) may be used; or k may be taken as the geometrical mean of the values obtained from Eq. (XII) by putting, 1st, a = a and 2nd, a = b.

The differential equation is given in case the rate does not follow a simple law, and the integrated expression is then often omitted.

Progressive Change in k.—↓ (resp. ↑) = "the value of k is greatest at the beginning (resp. end) of the reaction."

Temperature Coefficient.—The effect of temperature will be exhibited approximately by $Q_{10} = \frac{k_{\theta+10}}{k_\theta}$ where k_θ is the value of k at $\theta°$; or more exactly by the constant A in the equation $\log_e k = A/T + J$ or $\log_{10} k' = -A'/T + J'$ where A' (resp. J') = $0.4343 \times A$ (resp. $\times J$). E (= RA, where R is the gas constant) has been called the "internal energy" (Rice), the "critical energy" (Marcelin), the "critical energy increment" (McC. Lewis) or the "activation heat" (Arrhenius).

EXPERIMENTAL DATA

First-Order Gas Reactions

Nearly all reactions of this class take place almost entirely on the surface of the containing vessel as shown by the increase of k with increasing ratio of surface to volume; and several investigators have expressed the opinion that *true* first-order reactions do not exist (417). However, as a result of recent work, several examples are known; *cf.* $SO_2Cl_2 \longrightarrow SO_2 + Cl_2$ and $N_2O_5 \longrightarrow N_2O_4 + 1/2O_2$ below. For nearly all these first-order gas reactions k has been shown to decrease at very low pressure (254.5, 411.5); and new theories have been advanced (419.5). The important qualitative result is that the new evidence favors the collision mechanism and not the radiation theory.

Decomposition of Phosphine

$$4PH_3 \longrightarrow P_4 + 6H_2$$

Manometric method; t in seconds (309).

T, °K	845	785	719	640	583
10^6k	540	2.1	0.81	0.19	0.053

The observed values have been smoothed by graphing. The calculated values are computed from the equation:

$$\log_{10} k = \frac{-18\ 963}{T} + 2 \log_{10} T + 12.130;\ cf.\ (160)$$

% G = % of reaction in the gas phase; 100 − % G = % on walls; t in seconds (517).

T, °K	10^3k		% G	T, °K	10^3k		% G
	obs.	calc.			obs.	calc.	
956	18.3	18.0	100	940	8.3	8.0	96
953	15.0	15.5	100	936	7.1	6.5	92
948	12.0	12.0	100	933	6.3	5.6	89
945	10.2	10.3	100	929	5.5	4.5	82
942	9.1	8.9	98	928	4.6	3.3	72
				918	3.8	2.5	66

Measurements in quartz vessels with and without addition of quartz powder; t in seconds; S/V = surface/volume; even at 1044°K the reaction is obviously not a homogeneous one (258).

S/V = 1 cm^{-1};	T, °K	1044	1018	998	970	946		
E = 49 500	10^3k	74	26.7	19.5	10.9	5.29		
S/V = 8.6 cm^{-1};	T, °K	1007	979	956	917	894	858	828
E = 41 800	10^3k	110	49	32	13.2	5.92	2.41	1.19
S/V = 15.7 cm^{-1};	T, °K	983	963	919	890	864		
E = 34 100	10^3k	110	70.7	30.8	19.2	8.89		

Rearrangement of Trimethylene to Propylene

$$(CH_2)_3 \longrightarrow CH_3CH{=}CH_2$$

Bodenstein and Wolgast's gas-stream method with analysis of condensate by density; t in seconds; E = 54 800 to 70 400; Q_{10} = 1.55; the reaction is influenced by the walls, whose effect can, however, be largely diminished (519).

°C	550	570	580	600	600	650
10^3k	6.87	15.2	22.2	44.7	45.7	146

Decomposition of Hydrogen Peroxide

$$H_2O_2 \longrightarrow H_2O + \tfrac{1}{2}O_2$$

Manometric method; t in minutes; k = 0.22 to 0.38 at 76.0°C; wall reaction (257).

Decomposition of Sulfuryl Chloride

$$SO_2Cl_2 \rightleftarrows SO_2 + Cl_2$$

Manometric method; t in minutes; wall reaction (257); at temperatures above 200°C in the dark, the equilibrium concentration of SO_2Cl_2 is negligibly small (514.5).

°C	$\frac{\log_e 2}{k}$	Q_{10}	E
211	172		
237	26.5	2.06	35 000
283	1.6	1.85	34 000

Decomposition of Sulfuryl Chloride.—(*Continued*)

Manometric method; t in minutes; at 320°C rate is uninfluenced by a 200-fold increase of the ratio of surface to volume. Concluded to be a *true* first-order reaction at and above this temperature (491.5).

T, °K	552.3	572.5	593.1	602.4
10^5k	6.09	27.1	132.1	274.2
E		46 400	51 850	55 700

Decomposition of Formic Acid

$$HCO_2H \longrightarrow H_2O + CO;\ k_{CO}$$
$$HCO_2H \longrightarrow H_2 + CO_2;\ k_{CO_2}$$

Manometric method; wall reaction dependent on nature of glass used; t in minutes; % P = % of $(CO_2 + H_2)$ formed (256); for catalysis by Al_2O_3, *v.* (16, 17).

°C	137.5	158	236	236	239	302	302	350
$10^4k'_{CO}$	0.49	3.6	12.1	11.4	14.4	46.5	58.0	159
% P	1.5	1.6	2.5	9.0	3.4	10.8	14.4	29.1

°C	237	302	302	350	E = 12 000 (CO)
$10^4k'_{CO_2}$	0.66	5.6	9.8	65	E = 24 500 (CO_2)

Decomposition of Nitrogen Pentoxide

$$N_2O_5 \longrightarrow N_2O_4 + \tfrac{1}{2}O_2$$

Manometric method with correction for NO_2 formation; t in minutes;

$$E = 24\ 700;\ \log_e k = \frac{-12\ 443}{T} + 35.56\ (132)$$

°C		65	55	45	35	25
10^3k	obs.	290*	90.0	29.9	8.08	2.03
	calc.	286	93.2	28.3	7.90	(2.03)

°C		25	20	15	0
10^3k	obs.	1.91†	1.17†	0.624†	0.0472†
	calc.	2.03	0.992	0.475	0.0440

* Average using Bodenstein's calculations (51).

† Vapor saturated with solid N_2O_5; values less accurate.

Effect of NO_2 at the beginning of the reaction

According to later measurements by Daniels *et al.* (133, 134, 560), traces of NO_2 are necessary for a smooth monomolecular course of the reaction, which would thus have an autocatalytic induction period. However, White and Tolman (549.5) have found no evidence of this effect at the lowest concentration measurable, and conclude that the reaction is monomolecular in its initial stage.

Colorimetric method; t in minutes; the values of k agree with those above.

°C	20	25	35	40
Initial $p_{N_2O_5}$, mm	1.3–55	2.5–29	2.9	2.5
10^3k	1.03	2.19	8.37	14.8

Decomposition in solvents; gas-volumetric method; t in seconds (346).

°C	CCl_4			$CHCl_3$			Gas*
	10^4k	Q_{10}	E	10^4k	Q_{10}	E	10^4k
55	21.2						15.0
50	11.6	3.47	25 292	12.8			
45	6.11	3.60	26 070				5.0
40	3.22	3.77	25 242	3.81	3.33	24 252	
35	1.62	3.83	26 218				1.35
30	0.8415	3.96	24 222	1.025	3.73	24 648	
25	0.409		25 770				0.34
	Mean: 25 469			Mean: 24 450			

* (132, 133).

Higher-Order Gas Reactions

DECOMPOSITION OF NITRIC OXIDE

$$2NO \longrightarrow N_2 + O_2$$

Analysis with nitrometer; units: seconds and M/cm³; second-order k (278, 515); *cf.* (379).

T,° K	k	Q_{10}	A	T, °K	k	Q_{10}	A
1 620	191 800			1 201	624.6	1.11	15 970
1 525	47 059	1.16	36 440	1 108	228.3	1.12	14 400
1 355	3 843	1.16	30 390	962	39.82	1.13	12 740
1 252	1 073.6	1.13	21 000				

DECOMPOSITION OF NITROUS OXIDE

$$2N_2O \longrightarrow 2N_2 + O_2$$

Gas-density method; units: seconds and M/cm³; second-order k (276).

T, °K	k	A
986	6.72	32 800
1 078	110.9	30 800
1 168	977.0	31 900
		Mean: 31 800

Manometric method; units: seconds and M/l (255).

T, °K	Values of k, second-order				
1125	12.5	10.6			
1085	3.70	3.27	3.93	4.05	(4.47)
1053	1.38	1.59	1.82	1.91	
1030	0.84	0.85	0.77	0.98	1.14
1001	0.38	0.51			
967	0.135				
838	0.011				

The reaction is homogeneous since neither quartz powder nor Pt or Rh foil influences its rate.

DECOMPOSITION AND FORMATION OF HYDROIODIC ACID

$$2HI \underset{k_1}{\overset{k}{\rightleftharpoons}} H_2 + I_2$$

$$\frac{d[I_2]}{dt} = k[HI]^2 - k_1[H_2][I_2] \qquad (I)$$

$$\frac{[H_2][I_2]}{[HI]^2} = \frac{k}{k_1} = K_E \qquad (II)$$

Titrimetric method; k_1 (obs.)—4th column—by the gas-current method; k_1 (calc.) from Equation II above, and the relation $\log_e K_E = -90.48/T - 1.5959 \log_e T + 0.0055454T + 2.6981$; units: minutes and M/22.4l (49).

T, °K	k(obs.)	k_1(obs.)	k_1(obs.)	k_1(calc.)
556	0.0_6942	0.0_3119		0.0_4796
575	0.0_5326	0.0_3353		0.0_3239
599		0.00146		
629	0.0_4809	0.00676		0.00546
647	0.0_3230	0.0140		0.0146
666	0.0_3588	0.0379		0.0350
679		0.0568	0.0535	
683	0.00137	0.0659		0.0784
700	0.00310	0.172		0.164
703		0.250	0.225	
713		0.362	0.336	
716	0.00670	0.375		0.337
781	0.1059	3.58		4.21

$$\log_e k = \frac{-21\,922.5}{T} - 14.468 \log_e T + 0.02305T + 104.185.$$

$$\log_e k_1 = \frac{-21\,832}{T} - 12.872 \log_e T + 0.0055454T + 2.6981.$$

For discussion of theory of the reaction, *v.* (160, 336).

FORMATION OF HYDROBROMIC ACID

$$\begin{array}{ccc} H_2 + Br_2 & \xrightarrow{k} & 2HBr \\ a - x \quad b - x & & x \end{array}$$

$$\frac{dx}{dt} = k\frac{(a - x)(b - x)^{1/2}}{5.00 + \dfrac{x}{b - x}}$$

Titrimetric method; units: minutes and M/22.4l (52); *cf.* (380, 411).

°C	k	Q_{10}	°C	k	Q_{10}
301.3	0.0856		251.4	0.00260	2.00
277.5	0.0159	2.03	224.7	0.00036	2.25

FORMATION OF NITROSYL BROMIDE

$$2NO + Br_2 \longrightarrow 2NOBr$$

Manometric method; units: seconds and M/cm³; third-order k; homogeneous reaction plus some wall reaction (518, 518.5).

T, °K	258	265	273	279	286
$10^{-10}k$	1.4(?)	1.2	1.2	1.9	0.9(?)

FORMATION AND DECOMPOSITION OF NITROGEN DIOXIDE

$$\begin{array}{ccc} O_2 + 2NO & \underset{k_1}{\overset{k}{\rightleftharpoons}} & 2NO_2 \\ \uparrow \qquad \uparrow & & \uparrow \\ a - x \quad b - x & & x \end{array}$$

$$\frac{dx}{dt} = k(a - x)(b - x)^2 - k_1x^2$$

Manometric method; units: minutes and M/l; smoothed values (50); formation of NO_2.

T, °K	273	308	333	363	414
$10^{-6}k$	2.09	1.59	1.31	1.12	0.925
Q_{10}		0.912	0.932	0.949	0.963
T, °K	470	514	564	613	662
$10^{-6}k$	0.791	0.724	0.681	0.659	0.649
Q_{10}	0.972	0.980	0.988	0.993	0.997

k and k_1 calculated from K_E.

T, °K	NO_2-decomposition			NO_2-formation	
	k_1	k_1(calc.)	Q_{10}	$10^{-6}k$(calc.)	Q_{10}
592.0	61.0	66.4		0.670	
603.5	90.6	98.4	1.50	0.667	0.996
627.0	204	222	1.50	0.647	0.987
651.0	485	489	1.53	0.693	1.029
656.0	568	561	1.51	0.705	1.039

From 0 to 354°C the reaction of formation of NO_2 has a negative temperature coefficient or a fractional value for Q_{10} (98, 559).

DECOMPOSITION OF PHOSGENE

$$COCl_2 \xrightarrow{k} CO + Cl_2$$

$$\frac{d[CO]}{dt} = k([COCl_2] - \kappa)[Cl_2]^{1/2}$$

$$\kappa = \frac{[CO][Cl_2]}{K_E} \text{ and } K_E = \frac{[CO][Cl_2]}{[COCl_2]}$$

[CO] and [$COCl_2$] are of the same order of magnitude (10^{-3} to 10^{-4}).

Manometric method; units: minutes and M/l; $\log_{10} k = \dfrac{-11\,420}{T} + 15.154$; $\log_{10} K_E = \dfrac{-5850}{T} + 5.50$; homogeneous gas reaction (110).

T, °K	655	685	715	745	782
$100k$(obs.)	0.53	2.95	15.1	67.6	354.0
$100k$(calc.)	0.52	3.03	15.2	66.8	354.0

Summary of Gas Reaction Data According to Trautz (516)

Units: seconds and M/cm^3

$$\text{Second-order: } \log_{10} k = \frac{-A'}{T} + \frac{1}{2}\log_{10} T + J'$$

Reaction	A′	J′	Authority
$H_2 + O_2 \rightarrow H_2O$	10 141	12.7	Bodenstein
$H_2 + I_2 \rightarrow 2HI$	8 640	13.7	Bodenstein
$2HI \rightarrow H_2 + I_2$	9 630	13.4	Bodenstein
$HI + O_2 \rightarrow H_2O + I_2$	5 600	11.9	Trautz and Helmer
$N_2 + O_2 \rightarrow NO$	18 800	11.4	Nernst and Jellinek
$2NO \rightarrow N_2 + O_2$	13 700	10.3	Nernst and Jellinek
$2O_3 \rightarrow O_2$	5 760	14.1	Warburg
$NO + Cl_2 \rightarrow NOCl_2$	4 220	12	Trautz and Schlueter
$NOCl_2 + NO \rightarrow NOCl$	3 940	12	Trautz and Schlueter
$2NOCl \rightarrow NO + NOCl_2$	6 040	12	Trautz and Schlueter

$$\text{Third-order: } \log_{10} k = \frac{-A'}{T} - \log_{10} T + J'$$

Reaction	A′	J′	Authority
$2NO + Cl_2 \rightarrow NOCl$	1 220	14.6	Trautz, Wachenheim, Schlueter, Henglein
$2NO + Br_2 \rightarrow NOBr$	760	15.1	Trautz and Dalal

Additional references (86, 87, 88, 109, 116, 299, 440, 501, 502, 536).

Racemization

Hyoscyamine (Hy.) $\rightleftarrows$ Scopolamine (Sc.)

Polarimetric method; t in minutes; first-order reaction with reversal (194).

1 g Hy. with absolute alcohol to 15 cm^3 + 1 cm^3 N NaOH; $2k = 0.0148$ at 5°C.

1.048 g Hy. with absolute alcohol to 24.95 cm^3 + 0.5238 g tropine; $2k = 4.97 \times 10^{-6}$ at room temperature.

4.0173 g Sc. with absolute alcohol to 70 cm^3 + 8.51 cm^3 absolute alcohol containing 0.004017 mole NaOH; $2k = 0.0295$ at 3°C.

15.519 g alcohol solution of Sc. (of which 1 $cm^3 \approx 9.46$ cm^3 0.01N H_2SO_4) + 0.3736 g tropine; $2k = 4.42 \times 10^{-6}$ at room temperature.

The reaction is useful for determining $[OH^-]$.

Potassium Chromooxalate

$$K_3[Cr(C_2O_4)_3],\ l \underset{k}{\overset{k}{\rightleftarrows}} d$$

Polarimetric method; t in seconds (420); *cf.* (277, 513, 549)

In H_2O	°C	0	11	22	24	Q_{10}	E
	$2 \times 10^6 k$	149	239	542	598	1.77	9328

	% Acetone	H_2O, M/l	$2k$
In H_2O + Acetone, 22°C	0	55.55	0.000542
	40	33.33	0.000329
	60	22.22	0.000262

l-Menthone $\underset{k_2}{\overset{k_1}{\rightleftarrows}}$ d-Menthone; $k = k_1 + k_2$

According to Beckmann (33) the two menthones are not optical antipodes and hence $k_1 \neq k_2$.

Measurements in various solvents; k independent of direction. Catalyzed by alcoholates, quaternary ammonium bases, and strong acids but not proportionally to their concentration.

Slight catalysis by weak acids. Not influenced by neutral salts, by acetic esters, or by dimethylhydroresorcinols. The catalysis by alcoholates is not influenced by slowly saponifiable esters but rapidly saponifiable ones react with Na from the alcoholates and decrease the reaction velocity accordingly.

l-Menthone $\rightleftarrows$ d-Menthone.—(*Continued*)

Polarimetric method; t in minutes; catalyst, 0.02 (resp. 0.01)N alcoholate (resp. 0.01N HCl) (522, 523).

Alcoholate Solvent: alcohol	0.02N k', 20°C	0.01N k', 25°C	0.01N HCl k', 20°C
Methyl	0.00317		0.0067
Ethyl	0.00826		0.0150
n-Propyl	0.0107		0.0215
n-Butyl	0.0130	0.0092	
n-Heptyl	0.0165		
n-Octyl	0.0191		0.0492
Isobutyl	0.0147	0.0105	0.0265
Isoamyl	0.0159		0.0277
Isopropyl	0.0171		
sec.-Butyl	0.0336	0.0244	
sec.-Octyl	0.0572		
tert.-Butyl		0.0504	
Allyl		0.00200	0.0104
Benzyl		0.00118	0.0335

Values of $1000k'$ at 20°C in various solvents with 0.01N HCl

Solvent	C_6H_6	$C_6H_4(CH_3)_2$	C_6H_5Cl	$(C_2H_5)_2O$
$10^3k'$	2.3	2.0	6.9	0.4

Solvent	C_2H_5Br	CH_2BrCH_2Br	CCl_4	$CHCl_3$
$10^3k'$	3.4	10.8	5.3	47.1

For all reactions $Q_{10} = 2.31$–3.19; A′ = 3250–4250.

For determination of the "alcoholytic constant" of the type [acetoacetic ester] [alcoholate]/[Na acetoacetic ester] = K, and for theory of the reaction, *v.* (225); *cf.* (10, 427).

Transformation of Geometric Isomers

syn-Aldoxime $\xrightarrow{k}$ *anti*-Aldoxime (398, 399)

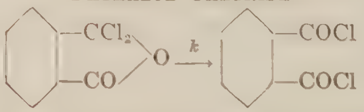
Method: change in rotation of the optically active solvent; t in minutes; $\theta = 20$°C. 5 g oxime in 95 g solvent. Values of $1000k$, (first-order):

syn-Anisaldoxime in dimethyl tartrate (3.0); in diethyl tartrate (1.8); in di-*n*-propyl tartrate (1.0); in dimethyl malate (5.0); in diethyl malate (6.7); in di-*n*-propyl malate (8.4) (398); *cf.* (399).

syn-m-Nitrobenzaldoxime in di-*n*-propyl tartrate (0.5) (398); *cf.* (399).

Intramolecular Transformation

Phthalyl Chloride



Reaction in liquid melt; method: initial freezing point; t in minutes; k (first-order) = 0.036 at 130°C; $Q_{10} = 1.6$ (90 – 170°) (130).

Diazoaminobenzene

$$C_6H_5NHN_2C_6H_5 \xrightarrow{k} C_6H_5N_2C_6H_4NH_2$$

Gas-volumetric method: t in hours; solvent, aniline; catalyzed by $C_6H_5NH_3Cl$; rate proportional to concn. of catalyst, $C_{cat.}$ (M/l); first-order k (216); *cf.* (204, 217).

°C	25			25	35	45	55	
$C_{cat.}$	0.1	0.2	0.3	0.1				
$10^3k'$	6.0	12.3	18.1	6.0	24.6	81.0	253	A′
Q_{10}					4.10	3.29	3.12	5355

Tribromobenzenediazonium Chloride

$$Br_3C_6H_2N_2Cl \xrightarrow{k} ClBr_2C_6H_2N_2Br$$

Gravimetric method; t in minutes; solvent, methyl alcohol; first-order k (239); $10^3k' = 0.83$ at 0°C = 1.93 at 4°C; $Q_{10} = 8.2$. The solid salt decomposes rapidly, the aq. soln. slowly, the alcoholic soln. at measurable rate (239).

ACETOPHENOXIME

$$C_6H_5C(NOH)CH_3 \xrightarrow{k} C_6H_5NHCOCH_3$$

Beckmann rearrangement; titrimetric method; *t* in minutes; catalyst, H_2SO_4; first-order *k* (490).

% H_2SO_4		68.5	93.6	94.6	97.2	98.2
$10^3k'$	60°C		1.1	1.3	4	7
	65°C	0.6	1.9	2.1		

CINCHONINE OR CINCHONIDINE $\xrightarrow{k}$ CINCHOTOXINE

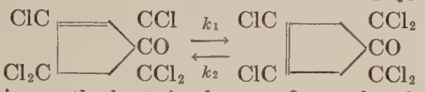
Gravimetric and polarimetric methods; *t* in hours; solvent, aqueous acids (39, 40, 41, 42, 44). Cinchonine at 99.7 ± 0.2°C; values of 1000*k'*, (first-order); $C_{cat.}$ in M/l.

$C_{cat.}$ \ Cat.	$C_2H_5CO_2H$	CH_3CO_2H	HCO_2H	$(CO_2H)_2$	HCl
0.15		5.60			1.63
0.175		7.12			0.77
0.20	11.7	9.4	6.2		0.3
0.40	29.6	23.9	12.1	4.0	
0.80	61.1	49.9	16.5		
2.00		90.1		0.7	

The value of *k* varies also with the initial concn. of the alkaloid. For theory of the reaction, *v.* (38, 39).

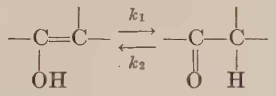
Tautomerism

HEXACHLORO-α-KETO-β-*R*-PENTENE IN THE LIQUID MELT



Gravimetric method; *t* in hours; first-order *k*, powerfully catalyzed by traces of H_2O or HCl. With material dried with P_2O_5, $k_1 = 0.049$, $k_2 = 0.078$. $K_E = 1.59$ at 210.5°C (321, 322).

ENOL⟶KETONE



First-order *k*; *t* in minutes:

I = Ethyl acetoacetate, $CH_3COCH_2CO_2C_2H_5$.
II = Methyl benzoylacetate, $C_6H_5COCH_2CO_2CH_3$.
III = Methyl mesityloxidoxalate, $(CH_3)_2C{:}CHCOCH_2COCO_2CH_3$.

Methods: (*a*) titration by Meyer's method; (*b*) bromine extraction; (331); *cf.* (138, 139, 141, 142); (*c*) viscosity; (*d*) refractometric; (*e*) $FeCl_3$ extraction; (*f*) $FeCl_3$, colorimetric.

Ester	Solvent	k_1	k_2	°C	Method	Lit.
I	Melt	0.0_355	0.0_446	15	(*a*)	(368)
I	H_2O	2.4	0.010	0	(*a*)	
I			0.013	0	(*b*)	
I			0.039	10	(*b*)	
I	0.1*N*HCl		0.018	0	(*b*)	
I	Alcohol	0.077	0.0105	0	(*a*)	
I	Hexane	0.0041	0.0035	0	(*a*)	
I	Melt	$k_1 + k_2 = 0.034$		25	(*c*)	(158)
I		0.0_3172	0.0_537	Rm	(*d*)	(306)
I		$k_1 + k_2 = 0.0178$		Rm	(*d*)	
I		$k_1 + k_2 = 0.613$		Rm	(*d*)	
I		0.0_397	0.0_42	Rm	(*d*)	
I		$k_1 + k_2 = 6.05$		Rm	(*d*)	
I	Petroleum ether	0.0192	0.0073	15	(*d*)	
I	H_2O		0.017	0	(*e*)	(266)
II	Melt	$k_1 + k_2 = 1.3$		Rm	(*d*)	(305)
II	Alcohol	0.10	0.04	0	(*a*)	(367)
III	Melt	0.0085	0.0_333	98	(*f*)	(307)
III	Alcohol	0.0_335	0.0_417	78	(*f*)	
III		0.0_455	0.0_52	Rm	(*f*)	

The reaction in the melt is very slow and depends on the nature of the walls, the presence of traces of impurities (*e.g.*, acids) and the previous history of the sample used. Acids are poor catalysts in H_2O and alcohol and good catalysts in non-ionizing solvents. The reaction in the gas phase is very slow even on the walls. For preparation of the pure tautomers, *v.* (370, 371).

HYDROXYTRIAZOLE ⟶ DIAZOMALONIC ESTER

$$\underset{A}{\text{Acid form}} \underset{k_2}{\overset{k_1}{\rightleftarrows}} \underset{N}{\text{Neutral form}}$$

Method: iodine titration of the acid form; *t* in minutes; first-order *k*. Methyl 1-methyl-5-hydroxytriazole-4-carboxylate $\underset{k_2}{\overset{k_1}{\rightleftarrows}}$ Methyl methylaminodiazomalonate. Ionization constant of the acid form = 2.8×10^{-3}.

Values for 50°C in various solvents (149)

	CH_3OH	$C_6H_5CH_2OH$	CH_3COCH_3
10^3k_1	0.120	0.278	1.36
10^6k_2	25.3	23.2	72.6
K_E	4.679	11.95	18.69

	$CH_3CO_2C_2H_5$	$C_6H_5NO_2$	$C_2H_5ONO_2$
10^3k_1	6.46	7.36	8.97
10^6k_2	117	73.6	98
K_E	54.25	100.0	98.9

$K_E = \frac{k_1}{k_2} = G\frac{S_N}{S_A}$ where S is the solubility (N- resp. A-form) in a given solvent and G is a universal constant independent of the nature of the solvent; *cf.* (260).

Values for 18°C in various solvents (149)

	CH_3OH	$C_6H_5CH_2OH$	CH_3COCH_3
K_E	3.27	8.62	14.15
S_N/S_A	6.29	13.28	20.82
G	0.52	0.65	0.68

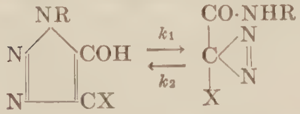
	$CH_3CO_2C_2H_5$	$C_6H_5NO_2$	$C_2H_5ONO_2$
K_E	51.63	99.0	89.91
S_N/S_A	84.61	157.7	171.3
G	0.61	0.63	0.53

Effect of solubility (g/l) on k_1 at 10°C. Methyl 1-phenyl-5-hydroxytriazole-4-carboxylate $\underset{k_2}{\overset{k_1}{\rightleftarrows}}$ Methyl anilinodiazomalonate (149).

Solvent	k_1	S_A	S_N	$k_1 \times S_A$
CH_3OH	0.00053	218	34.4	0.116
C_2H_5OH	0.00103	97.7	29.1	0.101
$C_6H_5CH_2OH$	0.0011	90	222	0.099
CH_3CN	0.0047	41.5	194	0.195
CH_3COCH_3	0.00527	56.5	206	0.298
$HCO_2C_2H_5$	0.00828	23.3	257	0.193
$CHCl_3$	0.0211	8.8	572	0.186
$CH_3CO_2C_2H_5$	0.0267	12	194	0.320
$C_6H_5NO_2$	0.046	6.5	346	0.299
$C_2H_5ONO_2$	0.055	3.2	317	0.176

Results obtained in water as the solvent indicate that the non-ionized acid form is the reacting molecular species, *v.* (149).

Effect of Chemical Constitution



k_1, measured; k_2, calculated from K_E; reaction in C_2H_5OH; values for very rapid or very slow reactions obtained by extrapolation to 25°C (149).

R	X	k_1	10^6k_2	K_E
H	$CONH_2$	0.0_53	1.3	2.26
H	CO_2CH_3	0.0_546	0.13	36
$C_6H_5CH_2$	CO_2CH_3	0.0_426	0.22	118
p-$C_6H_4CH_3$	$CO_2C_2H_5$	0.0094	78	120
C_6H_5	CO_2CH_3	0.01	34	300
p-C_6H_4Br	$CO_2C_2H_5$	0.046	83	555
p-$C_6H_4NO_2$	CO_2CH_3	0.6		Very large

Effect of Temperature

Values of 10^4k_1 for R = $C_6H_5CH_2$ and X = CO_2CH_3 (149)

Solvent	40°C	50°C	60°C	Q_{10}
CH_3OH		6.35	9.59	3.5
C_2H_5OH		10.0	42.3	4.2
CH_3COCH_3	15.2	65.1		4.3
$CHCl_3$	61.8	172		6.5

Ammonium Thiocyanate

$$NH_4CNS \underset{k_2}{\overset{k_1}{\rightleftharpoons}} CS(NH_2)_2$$

Reaction in the melt; titrimetric method; first-order k; t in minutes; at 170°C, $k_1 = 0.015$, $k_2 = 0.044$, $K_E = 1/3$ (25, 415, 528).

Decomposition Reactions

Nitramide

$$H_2N_2O_2 \xrightarrow{k} H_2O + N_2O$$

For preparation of nitramide, *v.* (512). First-order k; t in minutes; solvent, water; all values at 15°C (93).

$k = k_0 + k_cC_{cat.}$, where k_0 is the constant for the uncatalyzed reaction and k_c that with a catalyst of concn. $C_{cat.}$, M/l. All substances which decrease the $[H^+]$ of the solution act as catalyzers. $k_0' = 366$ to 398×10^{-6}, mean = 0.0_338.

Catalysis Constants for Anions of Acids

Values of k_c for the anions of weak monobasic acids, and their relation to the ionization constants, k_D

Acid	k_c'	$100k_D$	$10^5k_c' \times k_D{}^{0.83}$
Propionate	0.65	0.00134	5.9
Acetate	0.50	0.0018	5.8
Phenylacetate	0.23	0.0053	6.5
Benzoate	0.19	0.0065	6.3
Formate	0.082	0.021	7.2
Salicylate	0.021	0.1	6.2
Dichloroacetate	0.0007	5.0	5.8
			Mean: 6.2

In the case of polybasic acids the value of k_c for each anion was found to be similarly related to the corresponding ionization constant when the latter is corrected by a "statistical" factor, n, as illustrated below. The subscripts 1 and 2 refer to the first and second ionization stages, respectively.

Catalysis Constants for Anions of Acids.—(*Continued*)

Acid	$10^3k_{D_1}$	n	k_{c_1}'	$10^5k_{c_1}'(nk_{D_1})^{0.83}$	$10^5k_{D_2}$	n	k_{c_2}'	$10^5k_{c_2}'(nk_{D_2})^{0.83}$
Succinic	0.065	½	0.320	6.0	0.21	2	1.8	6.2
Malic	0.40	½	0.0765	6.4	0.69	2	0.72	6.8
Tartaric	0.97	½	0.0363	6.3	3.7	2	0.165	6.2
Phthalic	1.2	½	0.029	6.2				
Oxalic					4.5	2	0.104	4.8
Phosphoric	8.9	⅓	0.0079	6.3	0.0049	1	86	7.2
				Mean: 6.2				Mean: 6.2

Catalysis Constant for Bases

The "acid" equilibrium constant of the base, RNH_2, is $k_B = [RNH_2][H^+]\ [RNH_3^+]$

	Aniline	Quinoline	Dimethyl-aniline	Pyridine
10^5k_B	2.0	1.2	0.63	0.44
k_c'	0.531	1.9	2.7	4.6

For applications of the nitramide method to the determination of the ionization constants of (*a*) weak acids, (*b*) unsymmetrical dibasic acids, (*c*) H_2CO_3 (true constant), and (*d*) pseudo acids, *v.* (93).

Hydrogen Peroxide

$$H_2O_2 \xrightarrow{k} H_2O + \tfrac{1}{2}O_2 \text{ (aqueous solution)}$$

Homogeneous Catalysis

Catalysis by Alkalies

First-order k; t in minutes; θ = 40°C (100)

[NaOH]	0.0004	0.0016	0.008	0.04	0.16
10^3k	0.896	1.67	3.06	4.51	7.90

Base, $0.04N$	NaOH	KOH	NH_4OH	$Ba(OH)_2$
10^3k	4.51	4.68	3.98	2.26

Effect of temperature in $0.04N$ NaOH

°C	20	30	35	40	45	50	60	70
10^3k	1.06	3.08	5.16	7.90	13.4	17.3	38.9	58.8
Q_{10}		2.9	2.6		2.2		2.2	1.5

Catalysis by Iodide Ion

According to Abel (3), the reactions are $H_2O_2 + I_2 \longrightarrow 2H^+ + 2I^- + O_2$ [for kinetics, *v.* (5)] and $H_2O_2 + 2H^+ + 2I^- \longrightarrow 2H_2O + I_2$. For t in minutes; first-order $k_{cat.} = k[I^-]$. At 25°C, $k = 1.33$ (84, 534); *cf.* (89); = 1.4 (3); = 1.38 (241).

Neutral salts alone have slight influence. In the presence of iodide their pronounced catalytic effects increase in the order K^+, Na^+, Li^+ (241, 537, 538, 540).

In cases where the H_2O activity is constant, this catalysis by a neutral chloride is related to the Cl^--activity, a, by the simple rule, $k_{cat.}/a$ = constant, for the same salt concentration (240).

Catalysis by $K_2Cr_2O_7$

$$-\frac{d[H_2O_2]}{dt} = k[K_2Cr_2O_7][H_2O_2]$$

t in minutes; θ = 25°C; k = 20.9 to 34.5 in the interval $[K_2Cr_2O_7]$ = 0.009 to 0.0_43 (494); *cf.* (421, 495).

Heterogeneous Catalysis

By Colloidal Platinum

First-order k; t in minutes; θ = 25°C; Pt, 1 to 31 500 (76, 79), effect of age of Pt soln.

Pt-soln., days old	0	1	5
k'	0.023	0.025	0.022
k' (with Na_2HPO_4, 1 to 2000)	0.015	0.016	0.012

Effect of concentration of Pt soln.; k = constant × $[Pt]^n$ where n is a constant dependent upon the nature of the Pt preparation.

	1.13×10^6 [Pt]	32	24	16	12	6	4	3
n = 1.58	$10^3k'$(obs.)......	115	72	40	24	8.4	4.6	2.7
	$10^3k'$(calc.).....	115	74	39	24	8.2	4.3	2.7

Effect of Poisons

The catalytic action of colloidal Pt is diminished by various "poisons" most of which are likewise physiological poisons. With certain of these poisons the catalyst, toward the end of the reaction, partially "recovers" from the effects. This is illustrated by the following table for HCN on [Pt] = 1.03×10^{-5}.

10^6[HCN]...............	0	0.05	0.1	0.2	0.5	1	2
$10^2k'$, (begin)............	4.1	1.6	1.3	0.75	0.33	0.20	0.15
$10^2k'$ (end)...............	4.1	2.4	1.5	0.86	0.36	0.29	0.35

List of "Poisons" (* = Partial Recovery)

Powerful "poisons:" HCN*, ICN, I_2, $HgCl_2$, H_2S, $Na_2S_2O_3$, CO*, P, PH_3, AsH_3, $Hg(CN)_2$, CS_2.

Moderate "poisons:" aniline, hydroxylamine,* Br_2, HCl, oxalic acid, amyl nitrite, As_2O_3, Na_2SO_3,* NH_4Cl.

Weak "poisons:" H_3PO_3, $NaNO_3$, HNO_2, pyrogallol, nitrobenzene, HF, NH_4F.

Inactive substances: dilute $KClO_3$, ethyl and amyl alcohols, ether, glycerol, turpentine, chloroform.

Positive catalysts, ("tonics"): formic acid, hydrazine, dilute HNO_3.

By Colloidal Palladium

First-order k; t in minutes; θ = 25°C (75)

[Pd]	[NaOH]	k	[Pd]	[NaOH]	k
0	1:33 000	0	1:13 200*	1:6 000	0.0073
1:100 000	1:33 000	0.003	1: 6 600	1:3 000	0.0045
1: 13 000	1: 6 000	0.014	1: 6 600†	1:3 000	0.001
1: 4 400	1: 3 000	0.016	1:16 800	1:6 000	0.013
1: 13 200	1: 6 000	0.0103	1:16 800‡	1:6 000	0.0010

Poisoned by: *$[I_2] = 0.5 \times 10^{-7}$; †$[HgCl_2] = 10^{-3}$; ‡$AsH_3$ saturated.

By Colloidal Gold Catalysis in Alkaline Solution, *v.* (80)

In all of the preceding cases, the H_2O_2 reacts according to a first-order heterogeneous reaction [*v.* (95.8, 378)] if the reaction at the boundary is rapid in comparison with the rate of diffusion.

By Platinized Platinum

$$k' = \frac{1}{t}\log_{10}\frac{a}{a-x} = 0.4343\frac{SD}{\delta v}$$

D = diffusion coefficient; S = active surface; δ = thickness of diffusion layer; v = total volume, cm³; RPM = stirring rate, revolutions per min.; t in minutes; θ = 25°C (83).

v........	450	450	450	450	675	900	900	900	1350
RPM....	235	255	275	285	245	240	266	272	250
$10^4k'$.....	60	67	74	80	46	39	42	39	20

Temp. interval, °C..........	25–35	35–45	45–55
Q_{10}.........................	1.28	1.28	1.28

By Mercury

For pulsating catalysis on Hg surface, *v.* (19, 68)

The thinnest Hg layer on gold which exhibits catalytic action is *ca* 3 × 10^{-8} cm thick (85).

Dianthracene ⟶ Anthracene

$$C_{28}H_{20} \xrightarrow{k} 2C_{14}H_{10}$$

Gravimetric method; first-order k; t in minutes (349)

Solvent	°C	10^4k	Q_{10}
Phenetole..................	170	39.0	
	167	28.6	2.8
	160	13.9	2.8
Anisole....................	154	6.7	

The reaction is complete in the dark.

Na Isonitrosoacetophenone $\xrightarrow{k}$ Na Benzoate + HCN

$$C_6H_5COCH{:}NONa \xrightarrow{k} C_6H_5COONa + HCN$$

Colorimetric method; first-order k; t in minutes (489)

In H_2O	°C.............	35.6	60.1	69.0	70.0	Q_{10}
	$10^3k'$..........	0.62	2.3	4.5	4.8	3.5

Effect of solvent at 60.1°C

Aqueous	$10^3k'$	Solvent	$10^3k'$
0.1N NaOH..........	1.4	50% C_2H_5OH........	1.3
N NaOH.............	1.5	97% C_2H_5OH........	1.0
N NaCl..............	1.5	97% CH_3OH........	1.8
10N NaOH..........	2.2	100% CH_3OH........	1.7

Hydrazobenzene ⟶ Aniline + Azobenzene

$$2C_6H_5NHNHC_6H_5 \xrightarrow{k} 2C_6H_5NH_2 + C_6H_5N{:}NC_6H_5$$

Titrimetric method; first-order k; t in minutes (499)

In C_2H_5OH dried with Na, k = 0.00156 at 140.3°C. Authors conclude that free radicals are formed as intermediate step.

Xanthogenic Acid

$$CS(SH)(OC_2H_5) \longrightarrow CS_2 + C_2H_5OH$$

Autocatalyzed by the alcohol. $\frac{dx}{dt} = (k + k_0x)(a - x)$. At the beginning of the reaction and in media where the reaction is rapid k_0x is negligible in comparison with k and the reaction is of first order.

Titrimetric method; t in minutes (233)

Solvent	k', 0°C	k', 25°C	A′
CS_2............................		0.0_5132	
Ligroin............................	0.0_6190	0.0_5198	2500
Chloroform........................	0.0_654	0.0_5480	2972
Benzene..........................	0.0_680	0.0_568	3060
Nitrobenzene.....................	0.0_4644	0.0_3415	3548
Ether.............................	0.0_474	0.0_364	3080
Acetone..........................	0.00324	0.0343	3199
Alcohol...........................	0.143		

Reaction in benzene-alcohol mixture of normality N with respect to alcohol; θ = 25°C (233)

N............	0	0.01	0.02	0.174	0.5	1.0
k'............	0.0_568	0.0_4274	0.0_458	0.0_3294	0.0251	0.0423

For reaction in aqueous solution, *v.* (232).

Diacetone Alcohol ⟶ Acetone

$$CH_3COCH_2C(CH_3)_2OH \xrightarrow{k} 2CH_3COCH_3$$

In aqueous solution, the reaction is reversible, but for concentrations less than 10% it may be treated as complete. Dilatometric method; first-order k proportional to $[OH^-]$; t in minutes; $[OH^-]$ from conductivity; N = normality; θ = 25.2°C (308).

N	NaOH		
	k'/N	$10^2[OH^-]$	$k'/[OH^-]$
0.0942	0.2316	8.762	0.2490
0.0471	0.2357	4.503	0.2465
0.01884	0.2320	1.841	0.2375
0.00942	0.2358	0.929	0.2392
0.00471	0.2236	0.468	0.2250
0.002355	(0.1890)	0.235	(0.1894)

Diacetone Alcohol $\longrightarrow$ Acetone.—(*Continued*)

N	$Ba(OH)_2$		
	k'/N	$10^2[OH^-]$	$k'/[OH^-]$
0.0942	(0.2161)	8.006	0.2544
0.0471	0.2300	4.192	0.2584
0.01884	0.2243	1.771	0.2386
0.00942	0.2301	0.918	0.2362
0.00471	0.2252	0.466	0.2276

The average of $k'/N = 0.2298$, and hence on the assumption of complete ionization, $dx/dt = 0.5292[OH^-]\ (a - x)$ at 25.2°C.

Effect of neutral salts

M/l	[NaCl]	0	0.471	0.942	1.413
$[NaOH] = 0.0942$..	$10^3k'$	21.81	18.90	16.93	15.67
$[NaOH] = 0.0942$..	Salt	NaCl	$NaNO_3$	Na_2SO_4	$Na_2S_2O_3$
$[Salt] = 0.942$......	$10^3k'$	16.93	15.59	22.87	20.79

Method used to determine hydrolysis of Na_2CO_3 and ionization of ammonia and amine bases.

Nitrosotriacetoneamine $\xrightarrow{k}$ Phorone $+ N_2 + H_2O$

In aqueous solution with catalysis by OH^-. Gas-volumetric and (more accurate) manometric method; first-order k, t in minutes (117, 184, 185, 186, 386). $k/[OH^-] = 1.92$ at 30°C; mean of 12 measurements between 0.016 and $0.020N$ OH^-.

°C	18	30	40	50	60
$k/[OH^-]$, (obs.).........	0.612	1.92	4.51	10.15	22.0
$k/[OH^-]$, (calc. A = 8101)	0.637	1.92	4.51	10.06	21.3
Q_{10}....................		2.58	2.35	2.25	2.17

For application to determination of $[OH^-]$, *v.* (26); effect of neutral salts (21, 308); hydrolysis of soap solutions (350); acidity of $Sn(OH)_4$ solutions (123).

CO₂-Dissociation of Carboxylic Acids

Malonic Acid $\longrightarrow$ Acetic Acid $+ CO_2$

$$CH_2(CO_2H)_2 \xrightarrow{k} CH_3CO_2H + CO_2$$

Manometric method; first-order k; t in minutes; medium: the melt, stable and undercooled (254)

°C*..................	153.6	153.2	143.5	142.3	136.4
10^3k..................	65.0	62.7	24.6	22.0	12.5

°C*......................	134.2	133.6	129.4	125.9
10^3k......................	10.15	9.58	6.39	4.58

* $Q_{10} = 2.6$ over the whole range.

For the solid acid, k is not constant, but a value k_s can be obtained by extrapolation to $t = 0$. In the following table this value is compared with the value, k, for the undercooled melt.

°C...........	126.3	125.3	121.2	117.3	110.8
10^3k_s.........	0.58	0.51	0.113	0.094	0.028
10^3k.........	4.77	4.42	2.91	2.00	1.08
k/k_s.........	8	9	26	21	39

Solvent: acetic acid (340)

°C*..........	98.5	99.1	99.4	100.0	102.5	104.5
10^6k..........	650	708	739	830	1150	1460

* $Q_{10} = 3.85$ over the whole range.

Values of 10^3k at 110.8°C in different media are: the solid acid, 0.028; the undercooled melt, 1.08 (254); acetic acid, 3.41 (340); H_2O, 3.62 (35, 36).

$$CRR'(CO_2H)_2 \xrightarrow{k} CRR'HCO_2H + CO_2$$

Titrimetric method; first-order k; t in hours; solvent, H_2O (35, 36)

Malonic acid, $CH_2(CO_2H)_2$

°C..................	66.0	68.5	78.0	87.5	91.6	95.2	99.5
10^3k..................	0.27	0.9	4.4	16.4	28.8	47.3	75.5

°C..................	75.0	88.5	99.35	103.6	107.0	110.0
10^3k..................	3.36	18.9	75.5	108.4	154.4	201.9

Ethylmalonic acid, $C_2H_5CH(CO_2H)_2$

°C..............	80.0	86.0	95.0	102.0	105.0	110.0
10^3k..............	4.4	11.5	33.6	63.5	75.4	116.2

Benzylmalonic acid, $C_6H_5CH_2CH(CO_2H)_2$

°C..............	76.0	85.5	89.5	95.0	106.3	110.0
10^3k..............	14.3	48.6	83.3	116.1	259.0	476.5

Diethylmalonic acid, $(C_2H_5)_2C(CO_2H)_2$

°C......................	95.0	99.7	102.0	105.0	110.0
10^3k......................	9.1	35.5	55.5	73.0	122.5

Acid	Formula	k, 99.5°C
Phenylmalonic..........	$C_6H_5CH(CO_2H)_2$	1.9
Benzylmalonic..........	$C_6H_5CH_2CH(CO_2H)_2$	0.197
Chloromalonic..........	$CHCl(CO_2H)_2$	0.18
Allylmalonic............	$CH_2{:}CHCH_2CH(CO_2H)_2$	0.132
Tartronic...............	$CH(OH)(CO_2H)_2$	0.080
Malonic................	$CH_2(CO_2H)_2$	0.0757
Diallylmalonic..........	$(CH_2{:}CHCH_2)_2C(CO_2H)_2$	0.07
Methylmalonic..........	$CH_3CH(CO_2H)_2$	0.06
Ethylmalonic...........	$C_2H_5CH(CO_2H)_2$	0.051
Dichloromalonic.........	$CCl_2(CO_2H)_2$	0.05
Di-*n*-propylmalonic......	$(C_3H_7)_2C(CO_2H)_2$	0.05
Methylethylmalonic......	$(CH_3)(C_2H_5)C(CO_2H)_2$	0.035
Dimethylmalonic........	$(CH_3)_2C(CO_2H)_2$	0.029
Diethylmalonic..........	$(C_2H_5)_2C(CO_2H)_2$	0.028
Dibromomalonic.........	$CBr_2(CO_2H)_2$	0.02

Acetoacetic Acid $\longrightarrow$ Acetone $+ CO_2$

$$CH_3COCH_2CO_2H \longrightarrow CH_3COCH_3 + CO_2;\ \text{solvent, } H_2O$$

Both the undissociated acid (HA) and its anion (A^-) undergo the reaction:

$$\frac{d[CO_2]}{dt} = k_1[HA] + k_2[A^-]$$

Let k_D = the ionization constant and α the degree of ionization of the aceto-acid, then

$$\frac{dx}{dt} = k_1[(1 - \alpha) + k_2\alpha](a - x)$$

$$\frac{dx}{dt} = [k_1[H^+] + k_2k_D]\frac{(a - x)}{[H^+] + k_D}$$

k_1 is measured in strongly acid and k_2 in strongly alkaline solution. k_1 and k_2 together with a velocity measurement in an acetic acid-acetate solution give k_D. t in minutes (551); *cf.* (343). For preparation of the aceto-acid, *v.* (344).

°C	10^3k_1	10^3k_2	10^3k_D	Q_{10}
25	0.99	0.02	0.316	3.53(k_1)
37	4.5	0.08	0.24	3.16(k_2)

Catalysis by Aniline

This reaction is of interest because, as in the case of many biochemical reactions, there is a maximum catalytic effect at a given $[H^+]$. For details, *v.* (552).

Trichloroacetic Acid $\longrightarrow$ Chloroform $+ CO_2$

$$CCl_3CO_2H \xrightarrow{k} CHCl_3 + CO_2$$

First-order k; t in minutes; solvent, aniline (207). 10^3k = 0.040 at 25°C; = 0.80 at 45°C; $Q_{10} = 4.47$. Addition of picric acid does not influence the velocity.

Aminobenzoic Acid $\longrightarrow$ Aniline $+ CO_2$

$$C_6H_4(NH_2)CO_2H \xrightarrow{k} C_6H_5NH_2 + CO_2$$

Titrimetric method; first-order k; t in hours; solvent, H_2O; Temp. = B. P. of the solution (351)

Solution	10^3k
2 g Anthranilic acid in 150 cm³ H_2O................	27
3 g Anthranilic acid in 200 cm³ H_2O................	30
2 g *p*-Aminobenzoic acid* in 200 cm³ H_2O..........	15

* *m*-Aminobenzoic acid does not react.

d-Camphorcarboxylic acid $\longrightarrow$ Camphor + CO_2

First-order k; t in minutes (30, 69); reaction in aqueous solution; no catalytic effect by H^+ or OH^-

°C	78	88	98	Q_{10}
10^3k for the undissociated acid	0.214	0.669	2.12	3.14
10^3k for the anion of the acid			0.063	

In C_6H_6, A = 14 040	°C	68	78	88	98
	10^3k	0.305	0.958	2.91	8.48
	Q_{10}		3.14	3.04	2.91

At 98°C	In	$C_6H_5NH_2$	C_2H_5OH	C_6H_6
	10^3k	32.50	10.40	8.48

At 98°C	In	$C_6H_5OC_2H_5$	$(C_2H_5)_2O$	H_2O
	10^3k	7.36	3.02	2.12

In alcohol, esterification takes place also with a first-order $k = 0.0102$. Bases act as catalyzers; optically inactive bases act the same on the *d*- and the *l*-acids, but active bases act more powerfully on the *d*-acid (73, 75).

°C	Solvent	10^3k	
		d-	*l*-
80	Aniline	6.76	6.63
80	Acetophenone	1.14	1.15
90		3.57	3.55
70	Nitrobenzene	0.333	
70	Nicotine	4.88	4.34
70	20 cm³ Nitrobenzene + 1.02 cm³ Nicotine	3.02	2.79
70	10 cm³ Acetophenone + 1.00 cm³ Nicotine	2.77	2.33
75	10 cm³ Acetophenone + 1.65 g Quinidine	6.46	4.42

The *dl*-acid is made optically active by catalysis with an optically active base. The optical activity attains a maximum at the time,

$$t = \frac{1}{k_l + k_d} \log_e \frac{k_l}{k_d},$$

where k_l (resp. k_d), are the constants of the two isomers. For asymmetric synthesis, *v.* (74).

The catalytic action of bases in general can be interpreted in terms of two velocity constants, one for the free acid and one for its salt. For details, *v.* (77, 285).

Bromocamphorcarboxylic acid $\longrightarrow$ Bromocamphor + CO_2

First-order k; t in minutes (128, 128.5)

d- or *l*- acid in Acetophenone	°C	60	70	80
	10^3k	2.16	5.03	12.1
	Q_{10}		2.37	2.40

In ethyl benzoate as solvent the acid is polymerized (2x), and the decomposition is a second-order reaction. It is catalyzed by bases. Quinine catalyzes the *l*-acid; quinidine, the *d*-acid, more rapidly.

Dissociation of Carboxylic Acids with the Production of CO or HCO_2H

OXALIC ACID $\longrightarrow$ CO + CO_2 + H_2O

$$(CO_2H)_2 \longrightarrow CO + CO_2 + H_2O$$

First-order k; t in minutes; solvent, H_2SO_4 + various % H_2O. Even at 0°C the reaction is too rapid to be measured in H_2SO_4 containing 1% SO_3 (78, 338).

$\%H_2O$	0.60	0.70	0.80	1.00	1.20	1.50	2.00	3.00
10^3k, 70°C	18.1	13.1	10.2	6.8	4.9	3.15	1.93	0.94
$\%H_2O$	3.0	4.0	6.0	8.0	10.0	15.0	20.0	Q_{10}
10^3k, 98°C	23.7	14.6	6.9	4.0	2.22	0.73	0.294	3–4

FORMIC ACID $\longrightarrow$ H_2O + CO

$$HCO_2H \longrightarrow H_2O + CO$$

First-order k; t in minutes; solvent, 90% H_2SO_4 (365)

Reaction mixture; 0.610 g HCO_2H + v cm³ H_2SO_4				Reaction mixture: m grams HCO_2Na + v cm³ H_2SO_4				
v	°C	10^3k	Q_{10}	m	v	°C	10^3k	Q_{10}
25	18	3.09		0.483	40	18	3.49	
40	18	2.85		0.807	25	18	3.47	
			4.17					3.61
40	25	8.44		0.512	40	25	8.68	
25	25	8.90		0.738	25	25	8.95	

Measurements by Schierz; same units (434)

$\%H_2SO_4$	98.9	97.6	94.5	91.8	89.2	85.0
$10^3k'$, 25°C	320.0	106.0	31.5	10.5	2.38	0.751
$10^3k'$, 15°C		32.6	9.9	3.29		
E		18 520	19 670	19 720		

In acetic anhydride as solvent the mixed anhydride CH_3CO_2OCH is formed. For details of the reaction with various catalyzers, *v.* (535). For application of this reaction to the determination of acetic acid in acetic anhydride, *v.* (434).

CHLORAL HYDRATE

$$CCl_3CH(OH)_2 + NaOH \longrightarrow CHCl_3 + HCO_2Na + H_2O$$

The equilibrium:

$$CCl_3CH(OH)_2 + OH^- \rightleftarrows CCl_3CH(OH)O^- + H_2O \qquad (I)$$

is rapidly established in alkaline solution and is followed by the slower reaction:

$$CCl_3CH(OH)O^- \xrightarrow{k} CCl_3H + HCOO^- \qquad (II)$$

At low temperatures in strongly alkaline solutions the equilibrium (I) is displaced to the right and the net reaction is (II) with first-order k.

Titrimetric method; first-order k; t in minutes; reaction mixture: 1 liter, composed of a moles chloral hydrate and b equivalents of base, the titer being T, hence

$$k' = \frac{1}{t} \log_{10} \frac{b - T_\infty}{T - T_\infty} \cdot [OH^-] = b - a$$

Measurements at 0°C, with KOH and with a = 0.01 (164)

b	b − a	k'	$k'/(b - a)$
0.012	0.002	0.0062	3.10
0.014	0.004	0.0134	3.35
0.016	0.006	0.0204	3.40

For the first solution ($k' = 0.0062$) we have therefore

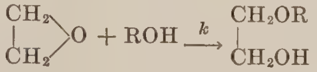
$$\frac{d[HCOO^-]}{dt} = 7.1[OH^-][CCl_3CH(OH)O^-] \text{ at } 0°C$$

Neutral salts catalyze the reaction as in the case of sugar inversion by acids.

With increasing temperature ($Q_{10} = 5$), hydrolysis of the chloral salt increases and the constant k' exhibits a progressive decrease; *cf.* (57, 412, 548).

Addition Reactions

ADDITION OF PHENOLS TO OLEFIN OXIDES IN 98% ALCOHOL



$$(CH_2)_2O + ROH \xrightarrow{k} CH_2OR{-}CH_2OH$$

With pure phenol the reaction proceeds slowly, catalyzed by the phenolate (59, 60):

$$(CH_2)_2O + RO^- \longrightarrow CH_2(OR)CH_2O^- \quad \text{(measurable)}$$

$$CH_2(OR)CH_2O^- + ROH \longrightarrow CH_2(OR)CH_2(OH) + RO^- \quad \text{(rapid)}$$

$$(CH_2)_2O + ROH \longrightarrow CH_2(OR)CH_2(OH) \quad \text{(net reaction)}$$

At *constant* concentration of phenol, k for olefin oxides is of first-order. Gravimetric method; t in hours; [ROH] = 1; [RONa] = 0.05; θ = 70.4°C (59, 60). (I) k' for ethylene oxide = $0.4343k$; (II) k' for propylene oxide = $0.4343k$.

Phenol	(I)	(II)
Mesitol	0.375	
ψ-Cumenol	0.338	0.125
Thymol	0.311	0.107
o-4-Xylenol	0.305	
m-6-Xylenol	0.301	
m-Dimethylaminophenol		0.105
p-Cresol	0.279	0.101
Carvacrol	0.257	0.101
m-Cresol	0.256	0.083
2, 5-Dimethylphenol	0.244	0.092
Eugenol	0.226	0.080
o-Cresol	0.225	0.078
Phenol	0.205	0.075
α-Naphthol	0.173	0.083
Guaiacol	0.171	0.064
β-Naphthol	0.144	0.053
p-Chlorophenol	0.108	0.042
o-Chlorophenol	0.104	0.050
m-Chlorophenol	0.101	0.043
2, 4, 6-Tribromophenol	0.099	0.065
2, 4, 6-Trichlorophenol	0.075	0.045
p-Benzeneazophenol	0.050	0.023
m-Hydroxybenzonitrile	0.044	0.0224
Salicylic nitrile	0.033	0.0193
m-Nitrophenol	0.032	0.0152
p-Hydroxybenzonitrile	0.026	0.0150
p-Nitrophenol	0.013	0.0075
o-Nitrophenol	0.0073	0.0035

REVERSIBLE ADDITION OF PCl_3 TO BENZALDEHYDE (125)

$$\underset{(a-x)}{PCl_3} + \underset{(b-x)}{C_6H_5CHO} \underset{k_2}{\overset{k_1}{\rightleftarrows}} \underset{x}{C_6H_5CHO.PCl_3}$$

$$\frac{dx}{dt} = k_1(a-x)(b-x) - k_2x$$

$$k_1 = \frac{K}{t\sqrt{q}}\log_e\frac{2Kx+m-\sqrt{q}}{2Kx+m+\sqrt{q}} \times \frac{m+\sqrt{q}}{m-\sqrt{q}}$$

$$m = -(Ka + Kb + 1)$$

$$q = (Ka + Kb + 1)^2 - 4K^2ab$$

$$k_1 = k_2K$$

Concn. in M/l; t in hours; θ = 25°C; solvent: *nil* or benzene (125)

Benzene, cm³	a = mole PCl_3	b = mole C_6H_5CHO	10^3k_1	K
0	0.0573	0.0573	(0.56)	0.126
0	0.0573	0.1146	(4.60)	0.216
0	0.1146	0.0573	(0.71)	0.533
25	0.0226	0.0226	5.1	0.416
25	0.0226	0.0452	4.8	0.424
25	0.0452	0.0226	2.5	0.182
25	0.0452	0.0452	4.0	0.266

Average values in the benzene solution: $k_1 = 4 \times 10^{-3}$; $k_2 = 13.3 \times 10^{-3}$; $K = 0.3$.

POLYMERIZATION OF CYANAMIDE TO DICYANDIAMIDE BY AQUEOUS ALKALIES

$$2CNNH_2 \xrightarrow{k} (CNNH_2)_2$$

The velocity in 0.125*N* NaOH is a maximum (223, 224) which accords with the relation:

$$\frac{d[(CNNH_2)_2]}{dt} = k[CNNH^-][CNNH_2]$$

ADDITION OF BROMINE TO DOUBLE BONDS

$$CHCl:CHCl + Br_2 \xrightarrow{k} CHClBrCHClBr$$

First-order k if the concn. of olefin as solvent is constant; t in hours; θ = 25°C (249); *cf.* (31, 248).

Olefin	Formula	$k' = 0.4343k$
cis-Dichloroethylene	CHCl: CHCl	0.024
trans-Dichloroethylene	CHCl: CHCl	0.012
Tetrachloroethylene	$CCl_2: CCl_2$	0.077

ADDITION OF OLEFINS TO ORGANIC ACIDS TO FORM ESTERS

Acetic acid scarcely reacts with amylene. The equilibrium is toward the side of the dissociation product. In general, ester formation is more nearly complete the stronger the acid.

$$CH(CH_3): C(CH_3)_2 + CHCl_2CO_2H \rightleftarrows CHCl_2CO_2C(CH_2CH_3)(CH_3)_2$$

$$CH(CH_3): C(CH_3)_2 + CCl_3CO_2H \rightleftarrows CCl_3CO_2C(CH_2CH_3)(CH_3)_2$$

Reaction with Excess of Amylene

The reaction is of the third-order with respect to the acid and runs to completion at low temperatures:

$$\frac{1}{V}\frac{dx}{dt} = k\left(\frac{1-x}{V}\right)^3$$

$$k' = \frac{1}{t-t_0}\left(\frac{1}{(1-x)^2} - \frac{1}{(1-x_0)^2}\right) = \frac{\text{constant}}{V^2}$$

Trichloroacetic Acid (382)

Titrimetric method; V = dilution per mole; t in minutes

Mole		V in cm³	°C	k'	$10^4k'V^2$
Acid	Amylene				
1	6.8	915	28.7	0.037	3.10
1	15.75	1986	28.7	0.0079	3.12
1	4.124	595.6	31.2	0.127	4.50
1	7.663	1018	31.2	0.041	4.25

$Q_{10} = 3.93$

The acid which combines acts therefore simultaneously as a catalyst according to its second power.

Equilibrium Reaction

$$\underset{(a-x)}{\text{Amylene}} + \underset{(b-x)}{\text{Acid}} \underset{k_1}{\overset{k}{\rightleftarrows}} \underset{x}{\text{Amyl Ester}}$$

Both reactions are catalyzed by the acid according to the second power, hence

$$\frac{1}{V}\frac{dx}{dt} = \frac{k}{V^4}(a-x)(b-x)^3 - \frac{k'}{V^3}[x(b-x)^2]$$

Integration for b = 1 gives approximately

$$C = \frac{k(1-\xi_1)^2\xi_2^2}{V^3(\xi_1+\xi_2)} = \frac{1}{t}\left[\log_e\frac{\xi_1(1-x)}{\xi_1-x} - (1-\xi_1)\left(1+\frac{1-\xi_1}{\xi_1+\xi_2}\right)\left(\frac{1}{1-x}-1\right)\right]$$

where

$$\xi_1 = x \text{ for } t = \infty$$

$$\xi_2 = \frac{a}{\xi_1} \text{ for } t \text{ in minutes.}$$

Dichloroacetic Acid and Amylene at 100°C (382)

Mole		ξ_1	ξ_2	C, average
Acid	Amylene			
1	5.9	0.650	9.035	0.00234
1	8.03	0.682	11.77	0.00139
1	8.03	0.682	11.77	0.00138

Trichloroacetic Acid and Amylene at 100°C

1	9.51	0.86	11.06	0.0087

The formation of *isomeric* esters does not affect the calculation.

FORMATION OF AMMONIUM SALTS FROM ALKYL HALIDES AND AMINES

$$RX + NR'R''R''' \xrightarrow{k} NRR'R''R'''X$$

Second-order reaction: titrimetric method; units: minutes and M/l.

Addition of Amines to Ethyl Bromoacetate in Absolute Alcohol Soln. at 0°C (115); *cf.* (114)

$$NR\,(CH_3)_2 + CH_2BrCO_2C_2H_5 \xrightarrow{k} BrNR(CH_3)_2CH_2CO_2C_2H_5$$

Base \ n	Values of 10^3k 2	3	4	5	6	7
$C_2H_5(CH_3)_nN(CH_3)_2$	11.4	10.7	10.3	11.2	10.9	
$(CH_3)_2CH(CH_2)_nN(CH_3)_2$	9.7	9.9	10.6	10.6		
$(CH_3)_2N(CH_2)_nN(CH_3)_2$	9.5	16.8	24.9	20.8	24.5	27.5
$CH_3O(CH_2)_nN(CH_3)_2$	6.7	9.3	10.6	10.5	11.5	

Addition of Aniline to ω-Bromoacetophenone in Various Solvents at Various Temperatures (127); *cf.* (126)

$$C_6H_5NH_2 + BrCH_2COC_6H_5 \xrightarrow{k} BrNH_2(C_6H_5)(CH_2COC_6H_5)$$

Solvent	10^2k, 27.8°	Q_{10}	10^2k, 37.8°	Q_{10}	10^2k, 47.8°	E*
Ethyl ether	0.0607					
Benzene	0.0644	1.53	0.0985	1.52	0.150	8 088
Chloroform	0.0970	1.92	0.186	1.61	0.299	10 760
Nitrobenzene	0.617	2.19	1.35	1.87	2.52	13 470
Acetone	1.39	1.93	2.69	1.64	4.40	11 080
Benzyl alcohol	2.08	2.12	4.40	2.10	9.24	14 290
n-Butyl alcohol	2.67	2.06	5.50	2.10	11.6	14 060
Ethyl alcohol	2.90	2.16	6.26	1.98	12.4	13 910
Methyl alcohol	3.89	1.92	7.48	1.91	14.3	12 440

* Computed on the basis of R = 1.985.

Addition of Pyridine to Allyl Bromide in Various Solvents at Various Temperatures (244)

$$C_5H_5N + CH_2{:}CHCH_2Br \longrightarrow CH_2{:}CHCH_2N(C_5H_5)Br$$

Solvent	10^3k, 28.3°	Q_{10}	10^3k, 38.3°	Q_{10}	10^3k, 56.5°	E
Toluene	0.231	2.25	0.517	1.97	1.86	15 100
Benzene	0.305	2.11	0.642	1.90	2.23	14 400
Ethyl alcohol	2.51	2.22	5.57	1.98	20.2	15 100
Acetone	5.05	2.02	10.2	1.82	33.8	13 600
p-Nitrotoluene	6.57	1.92	12.6	1.63	37.6	12 600
Acetophenone	10.4	1.95	20.3	1.42	52.6	12 100
Nitrobenzene	12.9	1.94	25.1	1.85	84.8	13 300

Mixed solvents; bimolecular k at 56.5°C

Mole		k	Mole		k
Acetone	Toluene		Aceto-phenone	Benzene	
1	0	0.0338	1	0	0.0526
0.88	0.12	0.0244	0.68	0.32	0.0340
0.75	0.25	0.0177	0.43	0.57	0.0203
0.59	0.41	0.0124	0.19	0.81	0.00913
0.40	0.60	0.00945	0	1	0.00227
0.23	0.77	0.00687			
0	1	0.00193			

Addition of Primary and Secondary Amines to Aromatic Halides

$$2C_6H_5NH_2 + C_6H_2Br(NO_2)_3 \xrightarrow{k} C_6H_5NHC_6H_2(NO_2)_3 + C_6H_5NH_3Br$$

(a − 2x) (b − x)

The effect of the $C_6H_5NH_3Br$ formed upon the bromide is 100 times slower than that of the free aniline so that only the above reaction is significant.

Calculation of bimolecular k (416)

$$k = \frac{1}{2t} \times \frac{x}{b(b-x)} \text{ for a = 2b}$$

$$k = \frac{1}{(a-2b)t} \log_e \frac{b(a-2x)}{a(b-x)} \text{ for a} \sim 2b$$

Solvent: absolute alcohol; units: hours and M/l; θ = 50°C; values of 10^2k (416)

Halide	Amine $C_6H_5NH_2$	$C_6H_5NHCH_3$
C_6H_3Cl (1) $(NO_2)_2$ (2, 4)	0.275	0.0295
C_6H_3Br (1) $(NO_2)_2$ (2, 4)	0.421*	0.0869
C_6H_3I (1) $(NO_2)_2$ (2, 4)	0.123	0.0212
C_6H_2Cl (1) $(NO_2)_3$ (2, 4, 6)	1.90	0.0493
C_6H_2Br (1) $(NO_2)_3$ (2, 4, 6)	3.31	0.269
C_6H_2I (1) $(NO_2)_3$ (2, 4, 6)	1.72	0.668

* Mean of 7 determinations with the following extremes:

a	b	10^2k
0.025	0.025	0.383
0.4	0.2	0.466

REVERSIBLE DECOMPOSITION AND FORMATION OF AMMONIUM AND SULFONIUM SALTS IN DIFFERENT SOLVENTS (229); *cf.* (230)

k_1 = first-order constant of decomposition.
k_2 = second-order constant of formation.
Titrimetric method; units: minutes and M/l; $k_1' = 0.4343\,k_1$.

Reversible Decomposition of *p*-Bromophenyldimethylallylammonium Bromide

$$BrC_6H_4NBr(CH_3)_2C_3H_5 \underset{k_2}{\overset{k_1}{\leftrightarrows}} BrC_6H_4N(CH_3)_2 + C_3H_5Br$$

Solvent	$10^4k_1'$ 25°	35°	Q_{10}	10^4k_2 25°	35°	Q_{10}
Tetrachloroethane	0.78	3.8	4.8	17	29	1.7
Chloroform	0.27	1.42	5.3	5.5	10.2	1.9
Nitrobenzene	0.80					
Tetrabromoethane	1.6					
Acetone		5.0				

Reversible Decomposition of Triethylsulfonium Bromide

$$(C_2H_5)_3SBr \underset{k_2}{\overset{k_1}{\leftrightarrows}} (C_2H_5)_2S + C_2H_5Br$$

Measurement at 25°C; the constant of formation, k_2, is corrected for the velocity of decomposition

Solvent	$10^4k_1'$	10^4k_2
Acetone	0.42	0.023
Acetone + 3.46% H_2O	0.04	0.035
Acetone + 7.11% H_2O	0	0.058

Decomposition of $(C_2H_5)_3SBr$, values of $10^4k_1'$

Solvent	A′	18°C	30°C	40°C	50°C	60°C	70°C	80°C	86°C	88°C	90°C	92°C	98°C
Tetrachloroethane	6680	0.072	0.59	2.89	13.4	55	230						
Nitrobenzene	6240	0.109	0.78	3.52	14.5	55	180						
Nitromethane	5990							47.0	90.0			171.0	
Ethyl acetoacetate	6460				12.8	49	194						
Amyl alcohol	7260				0.218	1.03	4.6	17.3			66		179
Propyl alcohol	7380					0.399	1.77	7.10			27.0		74.0
Benzyl alcohol	7459							3.9			15.9		47.0
Acetic acid	6087							3.5		8.0			26.5
Ethyl alcohol													26.5
Tetrabromoethane				3.8									

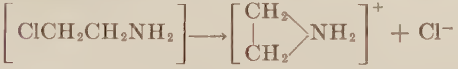
For the velocity of formation of $(C_2H_5)_3SI$, v. (106).

Coordination Reactions

By this is understood reactions of the type:

$$[Co(NH_3)_5Cl]^{++} + H_2O \longrightarrow [Co(NH_3)_5(H_2O)]^{+++} + Cl^-$$

and the analogous reaction of alkyl halogen amines in forming heterocyclic compounds:

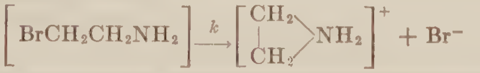


Alkyl Halogen Amines (188, 189, 190, 192)

In alkaline media the first-order reaction runs to completion with the formation of a heterocyclic compound; in acid media the reverse reaction runs to completion; in neutral media the reaction reaches a measurable equilibrium but is accompanied by a side reaction.

Method: volumetric and coagulation of As_2S_3 sol; k, first-order; t in minutes.

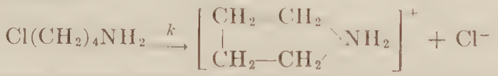
Conversion of β-Bromoethylamine into Ethyleneimine in aqueous alkaline solution:



°C	0	16.65	25
10^2k	0.068	0.89	2.9

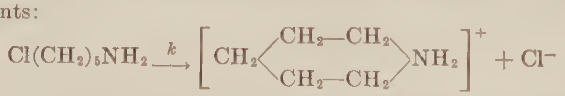
$$\log_e k = -\frac{12579}{T} + 38.770$$

Conversion of δ-Chlorobutylamine into Pyrrolidine in aqueous alkaline solution:



°C	0	25	Q_{10}
k	0.021	0.45	3.6

Conversion of ε-Chloroamylamine into Piperidine in various solvents:



The solvents immiscible with water were saturated with H_2O.

Solvent	10^2k, °C		
Aqueous alkali	0.029 (0°)	0.71 (25°)	2.98 (37°)
Ethyl alcohol, 91.2 Vol. %		0.10 (25°)	
Tetrachloroethane	0.019 (0°)	0.17 (24.8°)	0.45 (36.7°)
Nitrobenzene		0.13 (25°)	
Benzene		0.0049 (25°)	0.012 (36.1°)

$$\log_e k = -A/T + B$$

H_2O	Tetrachloroethane	Benzene
A = 10 440, B = 30.088	A = 7 231, B = 17.94	A = 7 575, B = 15.84

For the analogous reaction of $Br(CH_2)_5NH_2$ (resp. $I(CH_2)_5NH_2$) at 0°C in aqueous alkalies k = *ca.* 0.02 (resp. *ca.* 2).

KINETICS OF MONOMOLECULAR REACTIONS IN WATER

$$[Co(NH_3)_5X]^{++} + H_2O \xrightarrow{k} [Co(NH_3)_5(H_2O)]^{+++} + X^- \quad (1)$$

$$[Cr(NH_3)_5X]^{++} + H_2O \xrightarrow{k} [Cr(NH_3)_5(H_2O)]^{+++} + X^- \quad (2)$$

$$cis[Cr\,en_2Cl_2]^+ + 4H_2O \xrightarrow{k} cis[Cr\,en_2(O_2H_4)_2]^{+++} + 2Cl^- \quad (3)$$

en = $NH_2(CH_2)_2NH_2$.

$$[Cr(CNS)_6]^{---} + H_2O \xrightarrow{k} [Cr(CNS)_5(H_2O)]^{--} + CNS^- \quad (4)$$

First-order k; t in minutes

Reaction	X	k	°C	Lit.	Method
1	Cl	0.000132	25	(329)	(*a*)
1	Br	0.00039	25		
1	NO_3	0.00175	25		
2	Cl	0.00058	25	(188)	(*b*)
2	Br	0.003	25		
2	Cl	0.00002	0		
2	Br	0.00010	0		
2	I	0.01	0		
3		0.0032	25	(191)	(*b*)
3		0.00013	0		
4		0.00050	17	(47)	(*c*)

Reaction 1.—X = Cl: $\log_e k = -\frac{11067}{T} + 31.330$; $Q_{10} = 4.2$.

Reaction 2.—X = Cl: $\log_e k = -\frac{10890}{T} + 29.093$; $Q_{10} = 4.2$.

Reaction 3.— $\log_e k = -\frac{10430}{T} + 29.264$; $Q_{10} = 3.6$.

Methods: (*a*) = conductivity; (*b*) = coagulation; (*c*) colorimetric.

REVERSIBLE COORDINATION REACTIONS

$$[Cr(H_2O)_5(CNS)]^{++} + H_2O \underset{k_2}{\overset{k_1}{\rightleftarrows}} [Cr(H_2O)_6]^{+++} + CNS^-$$

$$\frac{dCNS^-}{dt} = k_1[Cr(H_2O)_5(CNS)]^{++} - k_2[CNS^-][Cr(H_2O)_6]^{+++}$$

Colorimetric method; units: minutes and M/l; solvent, H_2O (47)

	25°C	50°C
k_1	0.0000054	0.00040
k_2	0.0018	0.13

$$[Ir(NH_3)_5X]^{++} + H_2O \underset{k_2}{\overset{k_1}{\rightleftarrows}} [Ir(NH_3)_5(H_2O)]^{+++} + X^-$$

$$\frac{d[X^-]}{dt} = k_1[Ir(NH_3)_5X]^{++} - k_2[X^-][Ir(NH_3)_5(H_2O)]^{+++}$$

Conductivity method; units: hours and M/l; aqueous medium (327)

X	95°C		80°C	
	k_1	k_2	k_1	k_2
Cl..........	0.00231	0.118		
Br..........	0.0081	0.076	0.0028	0.0151
I..........	0.0081	0.054		
NO_3........	1.564	0.0475		

Coordination Reactions in Stages

The complete conversion of green dichlorotetraaquochromic chloride $[CrCl_2(H_2O)_4]Cl$ into blue hexaaquochromic chloride $[Cr(H_2O)_6]Cl_3$ takes place in dilute aqueous solution:

$$[CrCl_2(H_2O)_4]^+ \xrightarrow{k_1} [CrCl(H_2O)_5]^{++} \xrightarrow{k_2} [Cr(H_2O)_6]^{+++}$$

k_1 and k_2 are first-order constants.

Conductivity method; t in minutes; $\theta = 0°C$ (46, 328). s = Concn. of HCl added, M/l. a = Initial concn. of green dichlorochloride, M/l; k_1 refers to the beginning ($t = 0$) and k_2 to the end of the reaction.

10^3s	10^3a	k_1(obs.)	k_1(calc.)	k_2	Lit.
0	3.22	0.187		0.008	(46)
0	10.74	0.107		0.0035	
0.415	9.99	0.0362	0.0365	0.00465	
1.015	3.56	0.0180	0.0183	0.0031	
1.015	10.81	0.0182	0.0180	0.00231	
2.050	10.07	0.0104	0.0105	0.00131	
10.22	3.22	0.0042	0.0043	0.00031	
10.22	8.52	0.0044	0.0043	0.00032	
10.20	9.65	0.0044	0.0043	0.00032	
10.34	9.98	0.0044	0.0043	0.00032	
0	7.930	0.143	(0.133)		(328)
0	7.987	0.144	(0.134)		
0	7.948	0.131	(0.134)		
0.0824	8.072	0.098	0.0967		
0.2000	7.978	0.066	0.0644		
0.844	8.045	0.0204	0.0211	0.0038	
0.878	8.033	0.0205	0.0205	0.0038	
0.999	8.016	0.0179	0.0187	0.0033	
1.005	7.935	0.0179	0.0185		
1.005	7.815	0.0186	0.0185		
1.005	7.950	0.0190	0.0185		
4.196	8.133	0.0064	0.00642	0.00080	
8.000	7.933	0.0047	0.00463	0.00050	
9.815	8.050	0.0042	0.00419	0.00032	
10.09	7.565	0.0042	0.00418		

Neutral salts have no significant influence. The influence of temperature is great. For k_1, $Q_{10} = 4.80$ between 1 and 25°, $= 3.80$ between 20 and 25°; for k_2, $Q_{10} = 4.00$ between 20 and 25° (46).

At 25°C, k_1 and k_2 are expressed by the equations:

$$k_1 = 0.00272 + \frac{0.0000162}{[H^+]} \quad (46)$$

$$k_1 = 0.00265 + \frac{0.0000142}{[H^+]} \quad (328)$$

$$k_2 = \frac{3.1 \times 10^{-6}}{[H^+]} + \frac{5 \times 10^{-10}}{[H^+]^2} \quad (46)$$

k_1 and k_2 are aggregates of the velocity of conversion of the separate forms in which the reacting salts may appear. The hydrolytic forms act more rapidly than the ions. The first-order constants of the following forms have the values indicated (46):

$[CrCl_2(H_2O)_4]^+ = 0.00272$
$[CrCl_2(H_2O)_3(OH)] = 4.26$
$[CrCl(H_2O)_4(OH)]^+ = 0.36$

According to Lamb and Fonda (328) the hydrolysis constants are:

$$[CrCl_2(H_2O)_3(OH)][H^+] = 2.05 \times 10^{-6}[CrCl_2(H_2O)_4]^+$$
$$[Cr(H_2O)_5(OH)]^{++}[H^+] = 1.6 \times 10^{-4}[Cr(H_2O)_6]^{+++}$$

The large temperature coefficients of k_1 and k_2 are caused by the great increase of hydrolysis with increasing temperature. The reaction: green chromic salt ⟶ blue chromic salt is an example of the negative catalysis of hydrogen ion. For other work on negative catalysis, *see* (45, 514, 563).

Rearrangement of Dyestuffs and Indicators

Carbinol Form $\rightleftarrows$ Quinoid Form

Colorimetric method; t in minutes; aqueous solution with 7% alcohol; first-order $k' = 0.0434\ k$ (43); *cf.* (15, 38, 197, 236, 237, 374, 433).

Crystal violet: carbinol ⟶ quinone; $Q_{10} = 2.75$

HCl, N	k', 25°C	k', 30°C	k', 35°C	k', 40°C
0.0026	0.1001	0.1688	0.2751	
0.0051	0.0249	0.0412	0.0726	0.1209
0.0068	0.0160	0.0261	0.0440	0.0730
0.0151	0.0096	0.0153	0.0255	0.0430
0.0234	0.0090	0.0150	0.0243	0.0399

Crystal violet: quinone ⟶ carbinol: $Q_{10} = 2.04$

KOH, N	k', 25°C	k', 30°C	k', 35°C	k', 40°C
0.0033	0.0189	0.0263	0.0377	0.0535
0.0050	0.0290	0.0399	0.0570	0.0828
0.0083	0.0474	0.0651	0.0931	0.1334

Crystal violet: carbinol ⟶ quinone, at 25°C

HCl, N......	0.0432	0.0234	0.0151	0.0068	0.0051	0.0026
k'..........	0.01170	0.00899*	0.00969	0.01628	0.02482	0.10009

* Minimum at *ca.* 0.0234N HCl.

Malachite green at 25°C

HCl, N.......	0.065	0.023	0.015	0.007*	0.005	0.003
k'..........	0.1224	0.1092	0.0645	0.0480	0.0559	0.0628

* Minimum at *ca.* 0.007N HCl.

Phenolphthalein at 25°C

KOH, N................	0.11	0.15	0.22	0.33
k'......................	0.0280	0.0420	0.0707	0.1048

The velocity of decolorization of triphenylmethane dyes increases with the concentration of alkali; with basic dyes it is proportional to the $[OH^-]$; with acid dyes (*e.g.*, phenolphthalein) it increases with increasing $[OH^-]$ more rapidly than with the basic.

Retardation by neutral salts

Crystal violet in 0.013N KOH

Salt, N............	0	0.1	0.2	0.3	0.4	0.5
k' (KNO_3)..........	0.0712	0.0520	0.0411	0.0350	0.0309	0.0259
k' (KCl)............	0.0712	0.0540	0.0440	0.0380	0.0328	0.0290

Crystal violet in 0.004N HCl

Salt, N................	0.004	0.092	0.183	0.362
k' (KCl)................	0.0337	0.0163	0.0125	0.0105
k' (NaCl)...............	0.0334	0.0186	0.0133	0.0105

Phenolphthalein in 0.31N KOH

NaCl, N......	0	0.116	0.194	0.388	0.966	1.940
k'..........	0.1048	0.1204	0.1306	0.1451	0.1555	0.1625

Reactions of Sugars

Inversion of Cane Sugar

Sucrose + H_2O ⟶ Dextrose + Levulose

Earlier investigations showed that the reaction with respect to sucrose is of the first order and that its velocity is proportional to $[H^+]$ (23, 119, 396, 497).

Polarimetric method: t in hours; concn. in M/l; $\theta = 27°C$; catalyst, 57.50 g HCO_2H/l (428, 429).

$$\frac{dx}{dt} = kW(S - x) \text{ where } W = [H_2O] \text{ and } S = [C_{12}H_{22}O_{11}]$$

g $C_{12}H_{22}O_{11}$/l	g H_2O/l	W	$10^4k'W$	$10^4k'$(obs.)	$10^4k'$(calc.)
400	705.4	39.15	58.1	1.484	1.485
300	768.52	42.65	57.0	1.337	1.335
200	829.60	46.04	54.4	1.182	1.203
160	855.52	47.48	54.8	1.156	1.152
140	887.60	48.15	53.8	1.117	1.128
100	892.82	49.54	53.9	1.088	1.081
60	916.86	50.88	53.1	1.044	1.039

k' (calc.) from $k' = 0.000490e^{-0.03049}$W.

If C_1, C_2 . . . equal the concentration of the substances which determine the nature of the medium, and k_1, k_2 . . . equal the catalysis coefficients of these substances, the velocity coefficient, $k = k_0e^{k_1C_1+k_2C_2+k_3C_3+\cdots}$

Sugar inversion in $0.1N$ H_2SO_4; t in sec (284)

g $C_{12}H_{22}O_{11}$/l	MH_2O/l	10^6k				Q_{10}		
		20°C	30°C	40°C	50°C	30/20	40/30	50/40
100	51.95	4.43	18.3	67.3	229	4.13	3.68	3.40
200	48.45	4.79	19.7	73.7	255	4.11	3.74	3.46
300	44.99	5.21	21.2	80.4	281	4.07	3.79	3.49
400	41.62	5.54	22.9	88.0	308	4.13	3.84	3.50
500	38.09	5.95	24.5	95.3		4.12	3.89	
600	34.59	6.22	25.8	102.2		4.15	3.96	
700	30.94	6.29	26.6	109.2	394	4.23	4.11	3.64

For formulation in terms of activities, *see* (372). Definition of activities according to (335); *cf.* (90, 243, 401, 433). For sugar inversion with subsequent mutarotation of glucose and fructose, *see* (362).

Effect of Pressure

Polarimetric method; p in atm.; $\theta = 25°C$; catalyst, $\frac{1}{16}N$ HCl (121)

p	1	250	500	750	1000	1250	1500
$10^6k'$(obs.)	243	231	220	210	197.5	190	181
$10^6k'$(calc.)	(243)	233	222	212	202	191	(181)

k' (calc.) from $k' = a + bp$.

Sugar inversion in $0.5N$ HCl in aqueous alcohol with 10% $C_{12}H_{22}O_{11}$ (101).

First-order $k_1' = 0.4343k_1$, and second-order $k_2' = 0.4343k_2$, the latter calculated under the assumption that H_2O acts according to the first power of its concentration. Polarimetric method; t in minutes; $\theta = 25°C$.

Vol. % alcohol	0	16.7	25.0	40.0	50.0	60.0	75.0
$10^3k_1'$	2.19	2.13	2.04	1.92	1.76	1.85	2.08
$10^5k_2'$	4.27	4.91	5.19	6.07	6.67	8.77	16.03

For the use of sugar inversion to determine the hydrolysis of salts of weak bases, *see* (532, 533). For autocatalytic inversion by boric acid and its causes, *see* (55).

MUTAROTATION OR BIROTATION OF SUGARS

Mutarotation of Glucose in Aqueous Solution

$$\alpha\text{-Glucose} \overset{k_1}{\underset{k_2}{\leftrightarrows}} \beta\text{-Glucose}$$

$$k = k_1 + k_2 = \frac{1}{t}\log_e\frac{\xi}{\xi - x} = \frac{1}{t}\log_e\frac{\alpha_\infty}{\alpha_\infty - \alpha}$$

Polarimetric method; t in minutes; $\theta = 25°C$.

$$k = k_w + k_s[H^+] + k_a[OH^-]$$

k_w	k_s	k_a	Lit.
0.0221	0.594	22 450	(272, 273, 274, 275, 394)
0.0239	0.769	21 520	(323, 324)

For further references on mutarotation of sugars, *see* (29, 170, 172, 334, 362, 377, 400, 422, 521, 524).

Decomposition of Pine Shavings by Caustic Soda in Autoclave under Pressure of 6–9 atm. at 140–170°C (24)

The velocity of decomposition of the shavings (52 % cellulose, 48 % non-cellulose) is proportional to the concn. of NaOH and to those of the dissolved portions of cellulose and non-cellulose.

k_i = first-order constant for the non-cellulose; t in hours
k_c = first-order constant for the cellulose

°C	k_i	k_c	$k_i : k_c$
140	1.94	0.069	28
160	5.34	0.430	12.4
170	8.47	0.976	8.7
270			1*
A	9 004	16 120	

* The value, $k_i : k_c = 1$ for 270°C is extrapolated from A.

Ureide Formation of Sugars in Aqueous Solution

Polarimetric method: units: M/l and hours; $\theta = 25°C$; catalyst, N H_2SO_4 (435); *cf.* (526).

Glucose and Galactose

$$C_6H_{12}O_6 + CO(NH_2)_2 \overset{k_1}{\underset{k_2}{\leftrightarrows}} C_6H_{11}O_5NCONH_2 + H_2O$$

$$\frac{d[\text{Ureide}]}{dt} = k_1[\text{Sugar}]\,[\text{Urea}] - k_2[\text{Ureide}]$$

Sugar	k_1	k_2
Glucose	0.00260	0.00153
Galactose	0.02435	0.00645

Mannose

$$2C_6H_{12}O_6 + CO(NH_2)_2 \overset{k_1}{\underset{k_2}{\leftrightarrows}} (C_6H_{12}O_5N)_2CO + H_2O$$

Substance	Concentration		
	$t = 0$	$t = t$	$t = \infty$
Mannose	C_0	C	C_∞
Urea	C_0'	$C_0' - \frac{1}{2}(C_0 - C)$	
Ureide	0	$\frac{1}{2}(C_0 - C)$	

$$\frac{-dC}{dt} = k_1C^2\left\{C_0' - \frac{1}{2}(C_0 - C)\right\} - \frac{1}{2}k_2(C_0 - C)$$

$$\delta = \frac{1}{t}\left[\log_e\frac{(\beta - C_0)^2(\alpha + \gamma C + C^2)}{(\beta - C_0)^2(\alpha + \gamma C + C_0)^2} + \frac{2\beta + \gamma}{\sqrt{\alpha - \frac{1}{4}\gamma^2}}\right.$$
$$\left.\text{arctg}\frac{(C - C_0)\sqrt{\alpha - \frac{1}{4}\gamma^2}}{(\alpha - \frac{1}{4}\gamma^2) + (C + \frac{1}{2}\gamma)(C_0 + \frac{1}{2}\gamma)}\right]$$

$$\delta = k_1(\alpha + \beta\gamma + \beta^2),\ \alpha - \beta\gamma = \frac{k_2}{k_1}$$

$$\gamma - \beta = 2C_0 - C_0,\ \alpha\beta = \frac{k_2}{k_1}C_0,\ \beta = C_\infty$$

C_0	C_0'	C_∞	k_1	k_2	Lit.
0.4386	0.5	0.2074	0.0368	0.00527	(435)
0.4386	0.2412	0.2977	0.0367	0.00788	(526)

Hydrolysis or Saponification of Esters, Ethers and Acid Anhydrides

$CH_3CO_2CH_3 + H_2O \longrightarrow CH_3CO_2H + CH_3OH$ IN AQUEOUS SOLUTION

Influence of the concentration of the catalyst, HCl, on first-order k (in minutes), titrimetric method (330)

HCl, N	10^3k		Q_{10}
	25°C	35°C	
0.1005	0.653	1.663	2.547
0.5024	3.510	8.836	2.520
0.8275	6.001	15.26	2.542
1.800	16.09	37.84	2.353
2.429	20.78	63.47	3.054

Influence of concentration of ester, a, and of H_2O, w, upon hydrolysis constant (222)

$$\frac{dx}{dt} = k(a - x) \qquad (1)$$

$$\frac{dx}{dt} = k_1(a - x)w - k_2x^2 \qquad (2)$$

a*	w	$10^3k(1)$	$10^3k/w$	$10^3k_1(2)$	$10^3k_2(2)$
Reaction in 1N HCl at 25°C					
1.741	45.38	9.03	0.1991	0.1652	0.755
1.151	48.76	8.18	0.1679	0.1482	0.677
0.7093	50.94	7.64	0.1467	0.1392	0.636
Reaction in 0.1N HCl at 25°C					
1.156	49.69	0.726	0.01461	0.01302	0.0595
0.7013	51.86	0.690	0.01330	0.01236	0.0565
0.2425	54.25	0.606	0.01217	0.01177	0.0538
0.1304	54.86	0.606	0.01104	0.01093	0.0499

* At still higher concentrations of ester, $k(1)$ increases with time.

Reaction in a viscous medium (water-gelatin) (104)

k = First-order constant for minutes and 18°C.

k_r = Constant reduced to the same H_2O concentration (unit: pure H_2O at 18°C).

η = Viscosity measured with Scarpa viscometer and referred to that of 0.5N HCl.

HCl, N	% Gelatin	η	10^3k	10^3k_r
0.5	0	1.000	2.116	2.138
0.5	1.348	1.480	2.025	2.061
0.5	3.354	3.692	1.698	1.747
0.5	5.152	8.976	1.747	1.813
0.5	9.642	20.23	1.593	1.696
0.2	0	1.000	0.7598	0.7628
0.2	9.627		0.6502	0.6876

Reaction in the presence of sugar (103)

$$k' = \frac{1}{t}\log_{10}\frac{\xi}{\xi - x};\ k'_c = \frac{1}{tw}\log_{10}\frac{\xi}{\xi - x}$$

w = H_2O concentration; t in minutes; θ = 25°C; $\xi = x$ for $t = \infty$

HCl, N	% Ester	% Sugar	w	$10^4k'$	$10^6k'_c$
0.5	5	0	52.32	14.97	28.6
0.5	5	7.5	49.60	16.6	33.5
0.5	5	15.5	46.88	17.5	37.3
0.25	5	0	52.35	7.16	13.63
0.25	5	7.5	49.83	8.05	16.16
0.125	5	0	52.67	3.50	6.64
0.125	5	7.5	49.95	3.99	7.99
0.5	2.5	0	53.72	14.81	27.6
0.5	5.0	0	52.32	14.97	28.6
0.5	10.0	0	49.60	15.94	32.1

For the determination of hydrolysis constants of salts of weak bases from the velocity of hydrolysis of $CH_3CO_2CH_3$, *see* (550, 556).

$CH_3CO_2C_2H_5 + H_2O \longrightarrow CH_3CO_2H + C_2H_5OH$ in Aqueous Solution

Effect of Salts on Acid Hydrolysis

First-order k (minutes); $k' = 0.4343k$

	Values of $10^5k'$ (507)			Q_{10}	Q_{10}
	0°C	25°C	40°C	$\frac{25}{0}$	$\frac{40}{25}$
0.1N HCl	2.056	28.29	109.4	2.85	2.46
0.1N HCl + 1N KCl	2.480	34.45	132.9	2.86	2.46

Values of $10^5k'$ at 25°C in 0.1N HCl (241)

Salt \ N	0	0.5	1.0	1.5	2.0	3.0
KCl	28.8	31.45	34.3	36.6	39.2	42.8
NaCl	28.8	31.75	35.9	39.9	42.85	52.3

Values of $10^5k'$ at 25°C in 0.05N acid (18)

Acid	HCl	HNO_3	H_2SO_4
$10^5k'$	13.84 ± 0.06	13.83 ± 0.11	10.11 ± 0.15

In each of the following determinations, the catalyst was 0.05N solution of the acid of the salt listed (18); *cf.* (436).

KCl, N	3.60	3.00	2.50	2.00	1.50	
$10^5k'$	21.7	20.2	19.1	17.7	17.0	
NaCl, N	4.80	4.08	3.40	2.72	2.04	1.36
$10^5k'$	29.7	27.4	25.4	22.9	20.2	18.4
NH_4Cl, N	4.77	3.98	3.31	2.65	1.99	1.32
$10^5k'$	22.8	21.3	20.7	19.5	17.8	16.4
$BaCl_2$, N	2.92	2.42	2.02	1.62	1.22	
$10^5k'$	23.3	21.9	20.1	18.4	17.3	
$CaCl_2$, N	10.10	8.42	7.02	5.60	4.20	2.80
$10^5k'$	55.9	50.7	45.2	38.2	30.4	24.3
$MgCl_2$, N	7.28	6.06	5.06	4.04	3.02	2.02
$10^5k'$	47.8	43.3	36.2	31.2	25.4	21.1
KNO_3, N	2.25	1.85	1.56	1.25	0.94	
$10^5k'$	16.1	15.6	15.3	14.9	14.5	
$NaNO_3$, N	5.82	4.68	3.90	3.12	2.34	1.56
$10^5k'$	21.4	18.9	18.0	17.3	16.3	15.5
NH_4NO_3, N	7.95	6.63	5.30	3.98	2.65	
$10^5k'$	20.4	19.8	17.6	16.1	15.1	
$Ca(NO_3)_2$, N	7.70	6.42	5.32	4.28	3.20	2.14
$10^5k'$	22.1	20.5	19.4	18.3	16.9	15.7
$Mg(NO_3)_2$, N	6.30	5.24	4.36	3.50	2.62	1.76
$10^5k'$	20.8	19.4	18.2	17.2	16.5	15.7
K_2SO_4, N	1.08	0.90	0.60	0.30		
$10^5k'$	3.4	3.5	3.6	4.0		
$(NH_4)_2SO_4$, N	6.80	5.68	4.72	3.78	2.84	1.88
$10^5k'$	3.5	3.8	3.7	3.4	3.4	3.3
Na_2SO_4, N	1.92	1.60	1.07	0.53		
$10^5k'$	3.6	3.5	3.8	4.0		
$MgSO_4$, N	4.24	3.54	2.96	2.36	1.76	0.60
$10^5k'$	7.0	6.6	6.1	5.6	5.1	5.4

Catalyst, 0.03N HCl; 20°C; $10^5k'$ = 5.10 (406)

N	KCl	NaCl	LiCl	$BaCl_2$	$SrCl_2$	$MgCl_2$
1	6.39	6.37	6.36	6.31	6.30	6.42
0.6	5.95	5.94	5.90	5.88	5.86	5.88
0.3	5.45	5.45	5.46	5.43	5.42	5.50

Catalyst, 0.03N HBr; 20°C; $10^5k'$ = 4.94 (406)

N	KBr	NaBr	$BaBr_2$
1	5.80	5.94	5.91
0.6	5.53		5.53
0.3	5.23	5.25	5.22

Catalyst, 0.03N HNO_3; 20°C; $10^5k'$ = 4.93 (406)

N	KNO_3	$NaNO_3$	$Sr(NO_3)_2$
1	5.33	5.37	5.34
0.6	5.11	5.16	5.26
0.3	5.02	5.06	5.11

For the determination of hydrolysis constants of salts of weak bases from the velocity of saponification of $CH_3CO_2C_2H_5$, *see* (555, 558).

$CH_3CO_2C_2H_5 + NaOH \longrightarrow CH_3CO_2Na + C_2H_5OH$ in Aqueous Solution

Effect of concentration of NaOH and of neutral salts on k; titrimetric method, second-order k; units: M/l and minutes; θ = 24.7°C (21)

NaOH, N	0.05	0.025	0.0125	0.00625	0.003125
k	6.76	6.52	6.48	6.58	6.65
0.025N NaCl + N	NaCl	$NaNO_3$	CH_3CO_2Na	$Na_2S_2O_3$	Na_2SO_4
k	5.75	5.06	6.50	6.63	7.31

Effect of nature of the alkali and temperature on k (369)

Base	LiOH	NaOH	KOH	RbOH	CsOH
k, 18°C	3.92	3.98	4.01	4.00	4.03
k, 25°C	6.12	6.17	6.20	6.22	6.22
Q_{10}	1.89	1.87	1.86	1.88	1.86

Effect of neutral salts on k (193)

Salt, N	0	0.5KCNS	1KCNS	0.5KCl	1KCl
k, 25°C	6.76	5.49	4.79	6.10	5.99

Various concentrations of salts at 25°C (498)

Salt*	4N	2N	1N	0.5N
KCl	4.688	5.307	5.673	5.913
KBr		4.550	5.292	5.665
KI	3.267	4.155	4.898	5.505
KNO_3		5.978	5.356	5.666
K_2SO_4			7.159	6.903
$(CO_2K)_2$		7.136	6.790	6.636

* In absence of salt, k = 6.510

Effect of temperature (413)

°C	9.4	14.4	24.22	35.14	44.94
k(obs.)	2.307	3.204	6.151	12.096	21.648
k(calc.)	(2.307)	3.20	(6.151)	11.97	(21.648)

$\log_{10} k = -1780/T + 0.00754T + 4.53.$

Effect of pressure (122)

k_t by titrimetric method; k_c by conductivity method, *cf.* (531); p, pressure in atm.; $\Delta = \left(\frac{k_{p\text{ atm.}} - k_{1\text{ atm.}}}{k_{1\text{ atm.}}}\right) 100.$

$$k = a + bp \qquad (1)$$

$$\frac{d \log_e k}{dp} = \text{Constant} \qquad (2)$$

Effect of pressure.—(*Continued*)

p	k_t	k_c	Δ	$k(1)$(calc.)	$k(2)$(calc.)
1	1.22	1.21		(1.21)	(1.21)
250	1.26		3.7	1.29	1.28
500	1.35	1.37	11.9	1.36	1.35
750	1.44		18.5	1.44	1.42
1000	1.52	1.53	25.5	1.52	1.50
1250	1.59		30.9	1.59	1.58
1500	1.67	1.67	37.4	(1.67)	(1.67)

Effect of blood charcoal (320); blood charcoal, Merck (purified with HCl); θ = 25°C

mgC/100cm³	k	mgC/100 cm³	k
0	6.26 ; 6.23	745.1	2.61 – 1.66
401.2	3.58 – 2.60	1066.0	1.99 – 1.49

Reaction in aqueous alcohol solution (312)

Vol. % C_2H_5OH	50	75	95	100
k, 25°C	1.62	0.668	0.136	0.00753

θ = 25°C; 96.4 Wt. % C_2H_5OH. The H_2O content = 3.6 Wt. % or 3.6 M/l if it is assumed that all the soda is present as NaOH (547); α = calc. degree of dissociation of NaOH (assuming the mass law to hold true) with 0.02 used as the NaOH dissociation constant:

$$\frac{-d[CH_3CO_2C_2H_5]}{dt} = [CH_3CO_2C_2H_5][NaOH][0.12911(1 - \alpha) + 0.05710\alpha]$$

The undissociated base therefore saponifies more rapidly than its ions. The velocity increases greatly with increased water content of the alcohol. If the solution is prepared by dissolving metallic sodium and if the water content of the alcohol is not sufficient to combine all Na as NaOH, the bimolecular law no longer holds and the velocity is very small. This makes it probable that the saponification is entirely caused by NaOH and not by $NaOC_2H_5$; *cf.* in this connection (545, 546).

ALKALINE SAPONIFICATION OF ESTERS BY SALTS OF WEAK ACIDS

Slightly Hydrolyzed Salts (22, 26, 234, 325, 352, 369, 441, 479, 555, 557, 558)

Example:

$$\underset{(a - x)}{CH_3CO_2C_2H_5} + \underset{(b - x)}{KCN} + H_2O \rightleftarrows CH_3CO_2K + HCN + C_2H_5OH$$

$$\frac{dx}{dt} = kK\frac{(a - x)(b - x)}{x}\text{; units: minutes and M/l.}$$

k = Second-order constant of ester saponification by $[OH^-]$.
$K_w = [H^+][OH^-]$ = constant = ion product of H_2O.
K_s = dissociation constant of HCN.
$K = \frac{K_w}{K_s}$ = hydrolysis constant of KCN.

Ester	°C	k	Salt	10^5kK(obs.)	$10^{14}K_w$	10^5K(calc.)	$10^{10}K_s$(calc.)	Lit.
$CH_3CO_2C_2H_5$	24.2	6.22	KCN	7.46	1.00	1.20	8.33	(441); *cf.* (22, 26, 325)
			C_6H_5OK	58.0	1.00	9.32	1.07	
			Na_2CO_3	64.7	1.00	10.4	0.96	
$CH_3CO_2CH_3$	25.0	10.2	C_6H_5ONa	86.7	1.00	8.50	1.18	(234)
			p-ClC_6H_4ONa	27.3	1.00	2.68	3.74	
			o-ClC_6H_4ONa	14.8	1.00	1.45	6.91	
			2, 4-$Cl_2C_6H_3ONa$	0.86	1.00	0.084	119.0	
			2, 4, 6-$Cl_3C_6H_2ONa$	0.438	1.00	0.0429	232.0	
			p-$NaOC_6H_4NO_2$	0.25	1.00	0.025	400.0	
			p-$NaOC_6H_4CN$	0.878	1.00	0.0861	116.0	
$CH_3CO_2C_2H_5$	25.0	6.86	Leucine-Na	40.0	1.00	5.81	1.72	(555)
			Glycine-Na	40.1	1.00	5.85	1.71	
			Alanine-Na	37.4	1.00	5.46	1.83	
$CH_3CO_2C_2H_5$	10.3	2.29	KCN	2.58		1.128		(352)
	25.05	5.91	KCN	8.13		1.544		
	41.8	15.67	KCN	32.17		2.047		
$CH_3CO_2CH_3$	25.0	11.42	Oxyuracil-Na	5.38	1.20	0.480	25.0	(557, 558)
			Allantoin-Na	11.7	1.20	1.03	11.7	
			Hydantoin-Na	18.0	1.20	1.58	7.59	
			Methyluracil-Na	43.5	1.20	3.82	3.14	

Alkaline Saponification of Esters.—(*Continued*)

Ester	°C	k	Salt	10^5kK(obs.)	$10^{14}K_w$	10^5K(calc.)	$10^{10}K_s$(calc.)	Lit.
$CH_3CO_2CH_3$	25.0	11.42	α-Dimethyluracil-Na......	155.0	1.20	13.6	0.88	(557, 558)
			β-Dimethyluracil-Na......	185.0	1.20	16.2	0.74	
			Succinimide-Na..........	453.0	1.20	3.97	0.302	
			Theobromine-Na.........	104.0	1.20	10.8	1.11	
			C_6H_5ONa...............	89.0	1.20	9.23	1.30	
			Theophylline-Na.........	8.45	1.20	0.741	16.2	
			Paraxanthine-Na.........	6.16	1.20	0.540	22.2	
$CH_3CO_2C_2H_5$	18.0	3.98	NaCN..................	6.05		1.52		(369)
	25.0	6.17	NaCN..................	10.36		1.68		
$CH_3CO_2CH_3$	25.0	10.74	Na_2CO_3.................	110.0	1.00	10.2	0.977	(479)

The following values of Q_{10} hold for the constants kK and k of the reaction $CH_3CO_2C_2H_5 + KCN$, according to (352, 369):

°C......................	10.3–25.05	25.05–41.8	18–25	Mean
Q_{10} for $kK = \tau'$...........	2.18	2.28	2.16	2.20
Q_{10} for $k = \tau$.............	1.90	1.79	1.87	1.85

The relation between τ' and τ, according to (447, 449) is given by:

$$\log_e \frac{\tau'}{\tau} = \frac{10U}{RT(T + 10)}$$

where U is the heat of the reaction $OH^- + HCN = H_2O + CN^-$, which is considered constant over the temperature range 10°.

Strongly Hydrolyzed Salts

For the theory of the reaction, *see* (347).

Saponification of $CH_3CO_2C_2H_5$ by NaOH in the presence of sugars (120)

The following velocity constants were found at 25°C ($k = 6.86$), in the presence of sugars or high-order alcohols in $N/40$ solution of ethyl acetate and NaOH:

Sugar \ N	1/5	1/10	1/20	1/40	1/80
Cane sugar................	2.01	3.12	4.29	5.19	5.88
Invert sugar...............	0.38	0.67	1.17	2.08	3.38
d-Glucose................	0.79	1.37	2.32	3.69	4.79
d-Fructose...............	0.59	1.02	1.88	3.04	4.27
Mannitol..................	5.17	5.85	6.18	6.40	6.81

From this may be calculated the degree of hydrolysis of the corresponding sugar solution.

Alkaline Saponification, in Aqueous Solution, of Esters (General Formula HAR) Which are Themselves Weak (Resp. Pseudo) Acids

$$\begin{array}{ll} AR^- + H_2O \rightleftarrows HAR + OH^- & \text{(rapid)} \\ HAR + OH^- \longrightarrow HA^- + ROH & \text{(measurable)} \\ \hline AR^- + H_2O \longrightarrow HA^- + ROH & \text{(net reaction)} \end{array}$$

$$\frac{dx}{dt} = k[HAR][OH^-] = k[HAR]\frac{K_w}{K_s}\frac{[RA^-]}{[HAR]} = k_1[RA^-].$$

$k_1 = k\dfrac{K_w}{K_s}$ = First-order constant.

k = Second-order constant of alkaline saponification of HAR.

$K_w = [H^+][OH^-] = 1.3 \times 10^{-14}$.

K_s = Dissociation constant of the weak acid, HAR.

Example:

$$\begin{array}{l} CH_3C(ONa){:}\,CHCO_2C_2H_5 + H_2O \rightleftarrows CH_3COCH_2CO_2C_2H_5 + NaOH \\ CH_3COCH_2CO_2C_2H_5 + NaOH \longrightarrow CH_3COCH_2CO_2Na + C_2H_5OH \\ \hline CH_3C(ONa){:}\,CHCO_2C_2H_5 + H_2O \longrightarrow CH_3COCH_2CO_2Na + C_2H_5OH \end{array}$$

The disubstituted acetic acid ester which forms no salts with NaOH behaves as a normal (*i.e.*, neutral) ester (215, 218, 343, 359).

Titrimetric method; $\theta = 25°C$; units: minutes and M/l

Ester	k_1	$10^{11}K_s$	k	Lit.
$CH_3COCH_2CO_2CH_3$.........	0.0279	2.0	43.0	(343)
$CH_3COCH_2CO_2C_2H_5$........	0.0186	2.0	28.6	(215, 218)
$CH_3COCH(C_2H_5)CO_2C_2H_5$..		0.09	10.0 *ca.*	
$CH_3COC(CH_3)_2CO_2CH_3$.....			2.43	
$CH_3COC(CH_3)_2CO_2C_2H_5$....			0.76	(359)
$CH_3COC(C_2H_5)_2CO_2C_2H_5$...			0.0058	(215, 218)

The Three Constants of Saponification in Aqueous Solution

If (a − x) is the concentration of the ester, organic acid anhydride or ether, all of which have an "ether oxygen," then:

$$XOY + H_2O \longrightarrow XOH + YOH$$

Where X and Y represent alkyl or acyl, the general velocity equation is:

$$\frac{dx}{dt} = (k_w + k_s[H^+] + k_a[OH^-])(a - x)$$

where k_w = constant for water saponification, k_s for acid saponification, and k_a for alkaline saponification.

The units for all the constants quoted in the following are minutes and M/l.

For references on the general equation, *see* (92, 456, 476, 541, 542). For methods of determining k_s and k_a by means of buffer salts, *see* (423, 450, 451, 454, 458, 460, 467, 470, 476, 478, 479, 480, 481, 485).

Esters and ethers of polybasic acids and of poly-alcohols saponify in stages. As a rule, with esters of polybasic acids, the constant of the second saponification stage, k_s, holds for the undissociated ester-acid, and k_a for its anion.

Esters and ethers of poly-alcohols with dissimilar groups yield isomeric intermediate products. The latter, under the catalytic influence of acids and bases are capable of changing from one to the other; *cf.* (487).

If the velocities for different types of esters or ethers are to be intercompared, such comparison must be made through the "group constants;" that is, the constants reduced to the bases of a single "ether oxygen."

If the group constants of a poly-ester or ether are the same, the following simple relation holds: The velocity is directly proportional to the number of saponifiable groups present.

For the determination of the constant of the intermediate stages from the total net reaction, *see* the fundamental work of Wegscheider (544).

Influence of Temperature upon Acid Saponification of Esters; Titrimetric Method

Ester	10^3k_s			Q_{10}	Q_{10}	Lit.
	25°	35°	50°	$\frac{35}{25}$	$\frac{50}{35}$	
$CH_3CO_2C_2H_5$	6.77	15.93	49.69	2.35	2.14	(150)
$CH_2ClCO_2C_2H_5$	4.58	9.17	32.12	2.00	2.31	
$CH_2(CN)CO_2C_2H_5$	1.025	2.31	7.69	2.26	2.23	
$CH_3CH_2CO_2C_2H_5$	7.04	17.7	53.38	2.51	2.09	
$CH_3CHBrCO_2C_2H_5$	2.106	3.89	9.25	1.84	1.78	
$CH_3CHClCO_2C_2H_5$	2.85	5.69	18.74	2.00	2.21	
$CH_2ClCH_2CO_2C_2H_5$	0.975	2.39	8.61	2.45	2.35	
$CH_2BrCH_2CO_2C_2H_5$	0.815	2.16	5.45	2.65	1.85	

Ester	10^3k_s			Q_{10}	Q_{10}	Lit.
	25°	35°	45°	$\frac{35}{25}$	$\frac{45}{35}$	
$CH_3CO_2C_2H_5$	6.37	16.26	37.4	2.55	2.30	(155)
$CH_2(OH)CO_2C_2H_5$	6.83	16.62	38.5	2.43	2.32	
$CH_2(OCH_3)CO_2C_2H_5$	3.80	9.00	22.6	2.37	2.51	
$CH_2(OC_2H_5)CO_2C_2H_5$	3.56	8.75	21.7	2.46	2.48	
$CH_2(OC_3H_7)CO_2C_2H_5$	3.52	8.40	21.2	2.39	2.52	
$CH_3CO_2C_2H_5$	6.47	16.3	37.4	2.51	2.29	(156)
$CH_2(OH)CO_2C_2H_5$	7.04	17.3	39.2	2.45	2.26	
$CH_3CH_2CO_2C_2H_5$	7.16	17.9	40.6	2.50	2.26	
$CH_3CH(OH)CO_2C_2H_5$	7.32	17.8	39.6	2.43	2.22	
$CH_2(OH)CH(OH)CO_2C_2H_5$	1.85	4.39	10.1	2.43	2.20	
$CH_3CH(OC_2H_5)CO_2C_2H_5$	1.97	4.95	11.1	2.51	2.24	
$CH_2(OC_2H_5)CH_2CO_2C_2H_5$	1.43	3.52	8.47	2.45	2.41	
$CH_3CH_2CH_2CO_2C_2H_5$	5.21	11.0	23.7	2.09	2.17	(144)
$(CH_3)_2CHCO_2C_2H_5$	3.99	9.14	20.3	2.31	2.23	
$CH_3CH_2CH(OH)CO_2C_2H_5$	3.98	8.70	19.5	2.18	2.24	
$(CH_3)_2C(OH)CO_2C_2H_5$	2.10	5.12	11.2	2.43	2.19	
$CH_3CH(OH)CH_2CO_2C_2H_5$	1.07	2.76	6.4	2.57	2.33	
$(CH_3)_2CHCH_2CO_2C_2H_5$			10.6			(151)
$(C_2H_5)_2CHCO_2C_2H_5$			5.73			
$CH_3CH(CN)CO_2C_2H_5$	0.914	2.27	4.54	2.48	2.00	
$CH_2(CN)CH_2CO_2C_2H_5$	1.30	3.34	7.42	2.57	2.24	
$CH_3CH_2CH(CN)CO_2C_2H_5$	0.615	1.41	3.50	2.29	2.48	
$CH_3CH(CN)CH_2CO_2C_2H_5$		2.04	4.78		2.34	
$CH_3CH_2CH_2CH(CN)CO_2C_2H_5$	0.467	1.39	3.10	2.97	2.23	
$(CH_3)_2CHCH(CN)CO_2C_2H_5$	0.250	0.649	1.81	2.59	2.78	
$(C_2H_5)_2C(CN)CO_2C_2H_5$	0.258	0.650	1.44	2.53	2.15	
$CH_3CH_2CO_2C_2H_5$	7.12	17.71	40.53	2.49	2.29	(152)
$CH_3CH(OH)CO_2C_2H_5$	7.61	17.75	39.66	2.33	2.23	
$CH_2(OH)CH_2CO_2C_2H_5$	1.62	4.06	9.87	2.50	2.43	
$CH_3CO_2CH_2CH_3$	6.475	16.2	37.7	2.5	2.3	(154)
$CH_3CO_2CH_2CH_2(OH)$	4.715	11.73	27.9	2.5	2.4	
$CH_3CO_2CH_2CH_2(OCH_3)$		12.25	28.15		2.3	
$CH_3CO_2CH_2CH_2(OC_2H_5)$	4.65	11.76	27.95	2.5	2.4	
$CH_3CO_2CH_2CH_2Cl$	4.68	11.76	27.5	2.5	2.3	
$CH_3CO_2CH_2CH_2Br$	5.58	13.46	29.8	2.4	2.3	

Esters in which halogen has been substituted on the α-carbon of the alkyl group saponify with great rapidity.

Influence of Temperature upon Alkaline Saponification of Esters; Titrimetric Method

Ester	k_a		Q_{10}	Lit.
	0°	25°		
$CH_3CO_2C_2H_5$	1.17	6.56	1.99	(143)
$CH_2(OH)CO_2C_2H_5$	12.9	65.3	1.91	
$CH_2(OCH_3)CO_2C_2H_5$	36.4	128.0	1.65	
$CH_2(OC_2H_5)CO_2C_2H_5$	15.9	64.8	1.75	
$CH_3(OC_3H_7)CO_2C_2H_5$	12.7	52.1	1.76	

Influence of Temperature.—*(Continued)*

Ester	k_a		Q_{10}	Lit.
	0°	25°		
$CH_3CH_2CO_2C_2H_5$	1.14	5.94	1.94	(143)
$CH_3CH(OH)CO_2C_2H_5$	14.6	63.7	1.80	
$CH_2(OH)CH_2CO_2C_2H_5$	1.83	10.2	1.99	(152)
$CH_2(OH)CH(OH)CO_2C_2H_5$	9.02	57.3	2.10	(143)
$CH_3CH(OC_2H_5)CO_2C_2H_5$	2.07	9.29	1.82	
$CH_2(OC_2H_5)CH_2CO_2C_2H_5$	1.07	5.02	1.86	

Influence of Constitution of Ester on Velocity of Hydrolysis; Titrimetric Method (391); *cf.* (390)

Ester	k_a				
	0.2°	10°	20°	30°	40°
$CH_3CO_2CH_2CH_3$			5.08		
$CH_3CO_2CH_2CH_2CH_3$	1.03	2.15	4.23	8.10	14.95
$CH_3CO_2CH(CH_3)_2$	0.319	0.640	1.26	2.50	4.80
$CH_3CO_2CH_2CH_2CH_2CH_3$	0.945	1.94	3.93	7.58	
$CH_3CO_2CH_2CH(CH_3)_2$	0.838	1.76	3.54	6.75	12.9
$CH_3CO_2CH(CH_3)(C_2H_5)$	0.209	0.419	0.817	1.55	
$CH_3CO_2C(CH_3)_3$	0.0160	0.0369	0.0810	0.166	
$CH_3CO_2CH_2CH_2CH(CH_3)_2$	0.914	1.80	3.61	6.72	
$CH_3CO_2C(CH_3)_2(CH_2CH_2CH_3)$		0.0175	0.0348	0.0662	
$CH_3CO_2CH_2CH{:}CH_2$		4.29	9.08	17.05	
$CH_3CO_2CH_2CH_2CH_2OH$		3.32	6.94	13.8	
$CH_3CO_2CH_2C_6H_5$		4.58	9.90	19.4	
$CH_2(OH)CO_2CH_2CH_2CH_3$	11.1	22.8	44.7		
$CH_2(OH)CO_2CH(CH_3)_2$	3.54	6.96	13.7		

k_a as function of temperature:

$$\log_{10} k_a = -\frac{A'}{T} + B'T + C'$$

Ester	A′	B′	C′
$CH_3CO_2C_2H_5$	1780	0.00754	4.53
$CH_3CO_2CH_2CH_2CH_3$	2359.9	0.001528	8.2351
$CH_3CO_2CH(CH_3)_2$	883.8	0.019259	−2.5231
$CH_3CO_2CH_2CH_2CH_2CH_3$	1948.9	0.006839	5.2397
$CH_3CO_2CH_2CH(CH_3)_2$	1856.0	0.007903	4.5675
$CH_3CO_2CH(CH_3)(C_2H_5)$	1820.9	0.007179	4.0242
$CH_3CO_2C(CH_3)_3$	3300.7	−0.005920	11.9064
$CH_3CO_2CH_2CH_2CH(CH_3)_2$	1852.2	0.006817	4.8761
$CH_3CO_2C(CH_3)_2(CH_2CH_2CH_3)$	2419.5	0.000675	6.6014
$CH_3CO_2CH_2CH{:}CH_2$	4954.5	−0.027188	25.8337
$CH_3CO_2CH_2CH_2CH_2(OH)$	2528.8	0.001515	9.0281
$CH_3CO_2CH_2C_6H_5$	5352.8	−0.031077	28.3700
$CH_2(OH)CO_2CH_2CH_2CH_3$	2377.6	0.000754	9.5439
$CH_2(OH)CO_2CH(CH_3)_2$	303.5	0.025939	−5.4259

Ester	k_a	0.2°	10°	20°	30°	40°
$CH_3CO_2(CH_2)_2CH_3$	calc.	1.03	2.13	4.25	8.12	14.92
	obs.	1.03	2.15	4.23	8.10	14.95
$CH_3CO_2CH(CH_3)_2$	calc.	0.319	0.637	1.27	2.49	4.80
	obs.	0.319	0.640	1.26	2.50	4.80
$CH_3CO_2(CH_2)_3CH_3$	calc.	0.944	1.94	3.91	7.59	
	obs.	0.945	1.94	3.93	7.58	
$CH_3CO_2CH_2CH(CH_3)_2$	calc.	0.844	1.75	3.54	6.87	12.9
	obs.	0.838	1.76	3.54	6.75	12.9
$CH_3CO_2CH(CH_3)(C_2H_5)$	calc.	0.209	0.419	0.819	1.55	
	obs.	0.209	0.419	0.817	1.55	

Influence of Constitution.—(*Continued*)

Ester	k_a	0.2°	10°	20°	30°	40°
$CH_3CO_2C(CH_3)_3$	calc.	0.0160	0.0370	0.0807	0.166	
	obs.	0.0160	0.0369	0.0810	0.166	
$CH_3CO_2(CH_2)_2$-$CH(CH_3)_2$	calc.	0.910	1.82	3.57	6.74	
	obs.	0.914	1.80	3.61	6.72	

k_s of Acid Saponification for Different Mono-esters at 25°C; Titrimetric Method

Ester	k_s
HCO_2CH_3	0.145 (397.2)
$HCO_2CH_2CH_3$	0.187 (397.2); 0.1845 (353); 0.192 (476)
$HCO_2CH_2CH_2CH_3$	0.195 (397.2)
$HCO_2CH(CH_3)_2$	0.168 (397.2)
$HCO_2(CH_2)_3CH_3$	0.187 (397.2)
$HCO_2CH_2CH(CH_3)_2$	0.190 (397.2)
$CH_3CO_2CH_3$	0.00680 (397.2); 0.00659 (245)
$CH_3CO_2CH_2CH_3$	0.00658 (397.2); 0.00658 (391); 0.00682 (245)
$CH_3CO_2CH_2CH_2CH_3$	0.00680 (397.2); 0.00671 (245)
$CH_3CO_2CH(CH_3)_2$	0.00370 (397.2); 0.00360 (391); 0.00350 (467)
$CH_3CO_2(CH_2)_3CH_3$	0.00660 (397.2)
$CH_3CO_2CH_2CH(CH_3)_2$	0.00552 (148)
$CH_3CO_2C(CH_3)_3$	0.00740 (391); 0.00758 (467)
$CH_3CO_2C(CH_3)_2(CH_2CH_2CH_3)$	0.0283 (391)
$CH_3CO_2C(CH_3)(C_2H_5)_2$	0.0731 (391)
$CH_3CO_2C_6H_5$	0.00469 (467); 0.0046 (492)
$CH_3CO_2CH_2C_6H_5$	0.00654 (467); 0.0051 (492)
$CH_3CH_2CO_2CH_3$	0.00724 (397.2); 0.00708 (245)
$CH_3CH_2CO_2C_2H_5$	0.00706 (397.2); 0.00727 (245); 0.00716 (144)
$CH_3CH_2CO_2(CH_2)_2CH_3$	0.00724 (245)
$CH_3(CH_2)_2CO_2CH_3$	0.00444 (397.2); 0.00394 (245)
$CH_3(CH_2)_2CO_2C_2H_5$	0.00417 (245); 0.00460 (148); 0.00521 (144)
$(CH_3)_2CHCO_2CH_3$	0.00398 (397.2)
$(CH_3)_2CHCO_2C_2H_5$	0.00344 (397.2); 0.00409 (245); 0.00460 (148)
$CH_3(CH_2)_3CO_2C_2H_5$	0.00143 (245)
$(CH_3)_2CHCH_2CO_2C_2H_5$	0.00207 (148)
$(CH_3)_3CCO_2C_2H_5$	0.00292 (391)
$CH_2BrCO_2C_2H_5$	0.00492 (157)
$CO(NH_2)CO_2CH_3$	0.0020 (473)
$CO(NH_2)CO_2C_2H_5$	0.0015 (473)
$CH_3COCO_2C_2H_5$	0.00722 (397.2); 0.00816 (474)
$CH_3COCH_2CO_2C_2H_5$	0.000989 (484)
$CH_3CO(CH_2)_2CO_2C_2H_5$	0.00151 (397.2); 0.00156 (474)
$CH_3CO_2CH_2COCH_3$	0.00201 (397.2)
$CH_3CO_2(CH_2)_3COCH_3$	0.00595 (397.2)
$CH_3CO_2CH_2CO_2H$	0.0018 (265, 266)
$CH_3CO_2CH_2CO_2^-$	0.0060 (265, 266)

Values of k_s (397.2)

Alcohol	Formate	Acetate	Propionate	*n*-Butyrate
CH_3OCH_2OH		0.143	0.0925	
$CH_3CH_2OCH_2OH$		0.520	0.325	
$CH_3(CH_2)_2OCH_2OH$		0.510	0.319	
$HO(CH_2)_2OH$	0.121	0.00485		
$CH_3O(CH_2)_2OH$	0.121	0.00483	0.00503	0.00315
$CH_3CH_2O(CH_2)_2OH$	0.124	0.00476		0.00276
$CH_3(CH_2)_2O(CH_2)_2OH$	0.122			
$HO(CH_2)_3OH$	0.153	0.00599		
$CH_3O(CH_2)_3OH$	0.151	0.00574		
$CH_3CH_2O(CH_2)_3OH$	0.158	0.00579		
$CH_3(CH_2)_2O(CH_2)_3OH$	0.156			

Acid	CH_3-ester	C_2H_5-ester
$CH_2(OH)CO_2H$		0.00716
$CH_2(OCH_3)CO_2H$	0.00373	0.00393
$CH_2(OC_2H_5)CO_2H$	0.00367	0.00361
$CH_2[O(CH_2)_2CH_3]CO_2H$	0.00357	0.00357
$CH_2[O(CH_2)_3CH_3]CO_2H$	0.00334	
$CH_2[OCH_2CH(CH_3)_2]CO_2H$	0.00317	
$CH_3CH(OH)CO_2H$	0.00780	0.00766
$CH_3CH(OCH_3)CO_2H$	0.00239	
$CH_3CH(OC_2H_5)CO_2H$		0.00211
$(CH_3)_2C(OH)CO_2H$		0.00205
$CH_2(OCH_3)CH_2CO_2H$	0.00147	
$CH_2(OC_2H_5)CH_2CO_2H$		0.00133
$CH_3CH(OH)CH_2CO_2H$		0.00114
$CH_2(OH)CH(OH)CO_2H$	0.00181	
$CH_2(OCH_3)CH_2CH_2CO_2H$	0.00339	
$CH_2(OC_2H_5)CH_2CH_2CO_2H$	0.00324	
$CH_2(OCH_3)CH_2CH_2CH_2CO_2H$	0.00392	

k_s of Acid Saponification of Mono-esters at 40°C

Ester	k_s
$HCO_2C_2H_5$	0.51 (345)
$HCO_2CH_2CH_2CH(CH_3)_2$	0.479 (99)
$CH_3CO_2C_2H_5$	0.0197 (157); 0.0259 (99)
$CH_3CO_2(CH_2)_2CH_3$	0.0201 (157)
$CH_3CO_2CH_2CH:CH_2$	0.0214 (99)
$CH_2ClCO_2C_2H_5$	0.0152 (345)
$CH_2ClCO_2(CH_2)_2CH_3$	0.0119 (157)
$CH_2ClCO_2CH_3$	0.0166 (345)
$CH_2BrCO_2(CH_2)_2CH_3$	0.0153 (157)
$CH_3CO_2C_6H_5$	0.0152 (345)
$CHCl_2CO_2C_2H_5$	0.0244 (345)
$CH_3CH_2CO_2CH_3$	0.0283 (99)
$CH_3CHClCO_2CH_3$	0.0101 (99)
$CH_3CCl_2CO_2CH_3$	0.0243 (99)
$CH_3(CH_2)_2CO_2CH_3$	0.0160 (99)
$CH_3CH:CHCO_2CH_3$, Methyl crotonate	0.00102 (99)
$CH_3CH:CHCO_2CH_3$, Methyl isocrotonate	0.00453 (99)
$C_6H_5CO_2CH_3$	0.00014 (345)

k_a of Alkaline Saponification of Mono-esters at 0°C (144); Conductivity Method

Ester	k_a
$CH_3CO_2C_2H_5$	1.2
$CH_3CH_2CO_2C_2H_5$	1.1
$CH_3CH_2CH_2CO_2C_2H_5$	0.68
$(CH_3)_2CHCO_2C_2H_5$	0.46
$CH_3CH_2CH(OH)CO_2C_2H_5$	6.2
$CH_3CH(OH)CH_2CO_2C_2H_5$	2.1
$(CH_3)_2C(OH)CO_2C_2H_5$	1.6

k_a of Alkaline Saponification of Mono-esters at 25°C

Ester	k_a	Method	Lit.
$CH_3CO_2C_2H_5$	6.5	(*a*)	(177, 178, 531)
$CH_3CO_2C_2H_5$	6.2	(*b*)	(536.5)
$CH_3CH_2CO_2C_2H_5$	5.3	(*a*)	(177, 178, 531)
$CH_2(OH)CO_2C_2H_5$	75		

k_a of Alkaline Saponification of Mono-esters at 25°C.—(*Continued*)

Ester	k_a	Method	Lit.
$CH_3CH(OH)CO_2C_2H_5$	63.5	(*a*)	(177, 178, 531)
$C_6H_5CH_2CO_2C_2H_5$	12.4		
$C_6H_5CH(OH)CO_2CH_3$	157		
$C_6H_5CH(OH)CO_2C_2H_5$	66		
$C_6H_5CH(OH)CO_2CH_2CH_2CH_3$	55		
$C_6H_5CH_2CH(OH)CO_2C_2H_5$	40.1		
$C_6H_5CH(OCH_3)CO_2C_2H_5$	23.3		
$C_6H_5CH(OC_2H_5)CO_2C_2H_5$	15.7		
$C_6H_5CH(OCH_2CH_2CH_3)$-$CO_2C_2H_5$	13.3		
$C_6H_5CH(OH)CH_2CH_2$-$CO_2C_2H_5$	16.5		
$C_6H_5CH(OH)CH_2CO_2C_2H_5$	4.9		
$C_6H_5CH_2CO_2CH_3$	27.4		
$CO(NH_2)CO_2CH_3$	48 000	(*c*)	(473)
$CO(NH_2)CO_2C_2H_5$	22 000		
$CH_3COCO_2C_2H_5$	110 000	(*c*)	(474)
$CH_3COCH_2CO_2C_2H_5$	28.6	(*d*)	(218)
$CH_3COCH_2CH_2CO_2C_2H_5$	7.7	(*c*)	(474)
$CH_3CO_2CH(CH_3)_2$	1.57	(*d*)	(467)
$CH_3CO_2C(CH_3)_3$	0.090		
$CH_3CO_2C_6H_5$	82.0		
$CH_3CO_2CH_2C_6H_5$	11.8		
$CH_2(OCOCH_3)CO_2^-$	3.3	(*d*)	(218)
$1\text{-}CO_2^-(CHOCOCH_3)CH_2CO_2^-$	0.23		

Methods: (*a*) = conductivity; (*b*) refractometer; (*c*) buffer salts; (*d*) titrimetric.

k_a of Alkaline Saponification of Mono-esters at 20°C; Titrimetric Method

Ester	k_a	Lit.
$CH_3CO_2C_2H_5$	5.08	(391)
$CH_3CO_2CH(C_2H_5)_2$	0.340	
$CH_3CO_2C(CH_3)_2(C_2H_5)$	0.0372	
$CH_3CO_2C(CH_3)(C_2H_5)_2$	0.0172	
$CH_3CO_2CH_2CH:CH_2$	9.08	
$CH_3CO_2CH_2CH_2CH:CH_2$	5.73	
$CH_3CO_2C(CH_3)_2(CH_2CH:CH_2)$	0.0600	
$CH_3CO_2CH(CH_3)(C_6H_5)$	3.37	
$CH_3CO_2CH(C_2H_5)(C_6H_5)$	2.06	
$(CH_3)_3CCO_2C_2H_5$	1.18	
$CH_2(OH)CO_2CH_2CH(CH_3)_2$	37.2	
$CH_2(OH)CO_2CH(CH_3)(C_2H_5)$	9.25	
$CH_3CH_2CO_2C_2H_5$	5.44	(553)
$CH_2:CHCO_2C_2H_5$	5.78	
$CH_3CH_2CH_2CO_2C_2H_5$	3.213	
$CH_3CH:CHCO_2C_2H_5$	0.842	

k_a of Alkaline Saponification of Mono-esters at 15°C; Titrimetric Method (397.5)

Acid	CH_3-ester	C_2H_5-ester	n-C_3H_7-ester
		k_a	
$CH_2(OH)CO_2H$		29.0	
$CH_2(OCH_3)CO_2H$	55	33.8	27.2
$CH_2(OCH_2CH_3)CO_2H$	50.5	26.2	
$CH_2(OCH_2CH_2CH_3)CO_2H$	52.3	31.2	21.5
$CH_2(OCH_2CH_2CH_2CH_3)CO_2H$	51.7		
$CH_3CH(OH)CO_2H$	39.6	26.1	
$CH_3CH(OCH_3)CO_2H$	16.8		
$CH_3CH(OC_2H_5)CO_2H$		5.20	
$CH_2(OCH_3)CH_2CO_2H$	5.05		
$CH_2(OC_2H_5)CH_2CO_2H$		2.40	
$CH_2(OCH_3)CH_2CH_2CO_2H$	4.61		
$CH_2(OC_2H_5)CH_2CH_2CO_2H$	4.40		
$CH_2(OCH_3)CH_2CH_2CH_2CO_2H$	3.85		

Alcohol	k_a for: Acetate	Propionate	n-Butyrate	Isobutyrate
CH_3OCH_2OH	15.55	14.1		
$CH_3CH_2OCH_2OH$	13.1	11.9		
$CH_3CH_2CH_2OCH_2OH$	11.1	11.3		
$HOCH_2CH_2OH$	7.17			
$CH_3OCH_2CH_2OH$	6.20	5.30	3.41	3.11
$CH_3CH_2OCH_2CH_2OH$	5.82	5.00	2.98	2.49
$CH_3CH_2CH_2OCH_2CH_2OH$	5.54	4.90	2.99	2.48
$HO(CH_2)_3OH$	4.17			
$CH_3O(CH_2)_3OH$	3.51			
$CH_3CH_2O(CH_2)_3OH$	3.33			

k_a of Alkaline Saponification of Esters of Formic Acid; *cf.* (383, 531, 451)

Ester	°C	k_a	°C	k_a	Method	Lit.
HCO_2CH_3	18	1452			(*a*)	(165)
	18	1656			(*b*)	
	0	460	25	2400	(*c*)	(481)
$HCO_2C_2H_5$	0	330	25	1400	(*c*)	
			25	1080	(*d*)	(476)

Methods: (*a*) = residual current; (*b*) = conductivity; (*c*) = kinetic buffers; (*d*) = buffer salts.

The Three Saponification Constants for Ethyl and Vinyl Acetates at 25°C; Titrimetric Method (294, 485)

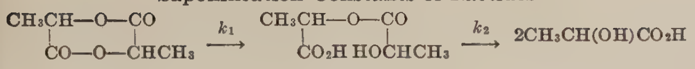
Ester	k_w	k_s	k_a
$CH_3CO_2CH_2CH_3$	0.0000000092	0.00546	9.83
$CH_3CO_2CH:CH_2$	0.0000068	0.00813	620

The Saponification Constants of Lactones at 25°C; Titrimetric Method

Lactone	k_w	k_s	k_a	
CH_3CHCH_2COO	0.0009		50	(281)
CH_2CH_2COO	0.0035		119	
$CH_2CH(CH_3)COO$	0.0039		140	
d-$OCOCH_2CHCO_2H$	0.00035	0.00096		(268)
$CH_2CH_2CH_2COO$		0.0138		(291)
$CH_3CHCH_2CH_2COO$		0.0106	24.7	(246, 265, 291)
d-$OCO(CHOH)_2CH$-$CHOHCO_2H$		0.00394		(361)
$COCH_2CHCO_2H$ O——CH_2		0.00883	43	(268)

As a rule, with β-lactones, k_w is large as compared with $[H^+]k_s$, with γ- and δ-lactones, it is small. With lactonic acid (d-malolactonic acid, d-saccharic acid-γ-lactone, paraconic acid) k_a applies for the anion and k_s chiefly for the undissociated lactone acid.

Saponification Constants of Lactides



$CH_3CH-O-CO / CO-O-CHCH_3 \xrightarrow{k_1} CH_3CH-O-CO / CO_2H\ HOCHCH_3 \xrightarrow{k_2} 2CH_3CH(OH)CO_2H$

Titrimetric method

Ester	°C	k_w	k_s	k_a	Lit.
Glycolide, k_1....	19.8	0.0179	0.119		(283)
Lactide, k_1......	19.8	0.00313	0.0611		
Lactide, k_1......	25	0.00459	0.1088	1.2×10^6	(423)
Lactide, k_2......	25		0.00203	19.5	

Saponification of Symmetrical Esters of Dicarboxylic Acids at 25°C

The constant of alkaline saponification holds for the anion; that of acid saponification for the undissociated ester acid.

Buffer-salts method (450, 451, 465, 468, 471, 474.5, 479, 480)

Ester	Stage*	k_s	k_a
Dimethyl oxalate..........	k_1	0.0192	1 760 000
	k_2	0.0096	90
Diethyl oxalate............	k_1	0.0106	530 000
	k_2	0.0053	36
Dimethyl malonate.........	k_1	0.00206	147
	k_2	0.00103	2.0
Diethyl malonate..........	k_1	0.00206	59
	k_2	0.00103	0.88
Dimethyl succinate.........	k_1		26
	k_2		2.8
Dimethyl glutarate.........	k_1		21.6†
	k_2		3.16†
Diethyl glutarate..........	k_1		10.0†
	k_2		1.63†
Dimethyl suberate.........	k_1		1.53†
	k_2		0.49†
Dimethyl azelate...........	k_1		1.24†
	k_2		0.42†
Dimethyl sebacate.........	k_1		1.2†
	k_2		0.43†
Dimethyl tartrate‡.........	k_1		363
	k_2		18
Dimethyl antitartrate......	k_1		258
	k_2		9
Dimethyl fumarate.........	k_1		414
	k_2		19
Dimethyl maleate..........	k_1		48
	k_2		0.72

* Saponification stage.

† These constants were measured in 50 vol. % aqueous alcohol; methyl alcohol for the methyl esters and ethyl alcohol for the ethyl esters.

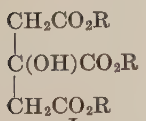
‡ The saponification constants for *d*-, *l*-, and *dl*-tartaric esters are the same.

For diethyl diethylmalonate $(C_2H_5)_2C(CO_2C_2H_5)_2$, the two constants of alkaline saponification at 85°C in 50 vol. % aqueous alcohol are 0.138 and 0.0122 (157.5).

Alkaline Saponification of Esters of Polycarboxylic Acids with Unlike Groups

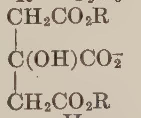
Ethyl citrate in aqueous solution; titrimetric method (405)

$R = C_2H_5$



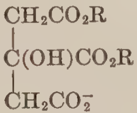
$CH_2CO_2R-C(OH)CO_2R-CH_2CO_2R$

I



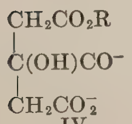
$CH_2CO_2R-C(OH)CO_2^--CH_2CO_2R$

II



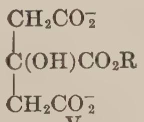
$CH_2CO_2R-C(OH)CO_2R-CH_2CO_2^-$

III



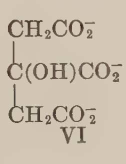
$CH_2CO_2R-C(OH)CO^--CH_2CO_2^-$

IV



$CH_2CO_2^--C(OH)CO_2R-CH_2CO_2^-$

V



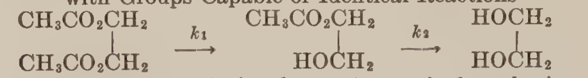
$CH_2CO_2^--C(OH)CO_2^--CH_2CO_2^-$

VI

Ethyl citrate.—(*Continued*)

Reaction	k_a		
	15°	23°	30°
I ⟶ III...........	63.7	98.9	149.8
III ⟶ V...........	2.92	4.28	5.14
II ⟶ IV...........	0.841	1.48	2.27
V ⟶ VI...........	0.0149	0.0283	0.0409
IV ⟶ VI...........	0.132	0.238	0.302

Saponification, in Aqueous Solution, of Esters of Poly-alcohols with Groups Capable of Identical Reactions



$CH_3CO_2CH_2-CH_3CO_2CH_2 \xrightarrow{k_1} CH_3CO_2CH_2-HOCH_2 \xrightarrow{k_2} HOCH_2-HOCH_2$

k is the constant calculated on the equivalent basis. For $k_1/k_2 = 2/1$, $k = 0.5k_1 = k_2 =$ constant or more generally: if the velocity is directly proportional to the number of reacting groups in the molecule, *k* is constant.

Titrimetric method

Ester	k_s	°C	Lit.	k_a	°C	Lit.
$(CH_3CO_2CH_2)_2$.....				2.50	0	(313)
				12.54	19.8	
	0.00235	18	(363)	7.618	18	(364)
	0.00456	25.2		16.330	25	
$(CH_3CO_2CH_2)_4C$...	0.00432	25	(487)	20.5	25	(487)

The constants k_s (resp. k_a) calculated from equivalents are approximately constant.

Saponification of Esters of Poly-alcohols with Unlike Groups (*e.g.*, Glycerol) in Aqueous Solution

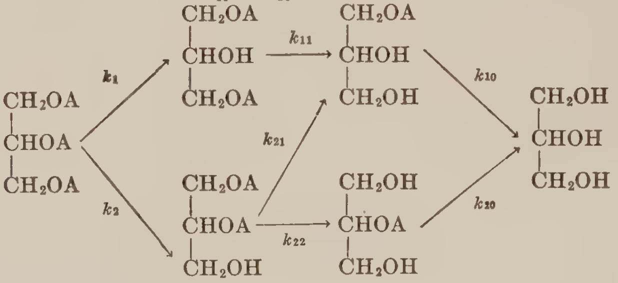
Titrimetric method; *k* = the "equivalent constant" for saponification of glyceryl acetate

	Monacetin	Diacetin	Triacetin	°C	Lit.
10^3k_s.......	2.27	1.93	2.00	18	(360)
10^3k_s.......	4.32	3.53	3.62	25.2	
10^3k_s.......			8.94	35	(562)
k_a......	8.13	7.85	7.89	18	(364)
k_a......	17.22	17.79	16.74	25	
k_a......	20.1–21.5	22.1–25.5	21.9–22.5	25	(491)

For further data on saponification of glyceryl esters, *see* (1, 196, 337, 508, 520).

The conditions for *k* = constant are (543):

$$k_1 + k_2 = 3k$$
$$k_{11} = k_{21} + k_{22} = 2k$$
$$k_{10} = k_{20} = k$$



where A = Acyl.

For the effect of rearrangement (acyl wandering) on the variation of *k*, *see* (487).

Saponification of Fats by NaOH in 95% Alcohol at 25°C; Titrimetric Method (271)

S = Saponification number; A = Acid number; I = Iodine number

Fat	S	A	I	$60k_a$
Almond oil...............	191.0	5.6	95.9	2.2
Lard......................	249.1	16.9	22.1	2.1
Castor oil................	177.9	4.0	85.5	2.1

Saponification of Fats.—(*Continued*)

Fat	S	A	I	$60k_a$
Codliver oil	182.4	2.3	156.4	2.3
Rapeseed oil	170.6	14.2	104.3	2.1
Linseed oil	188.4	7.3	177.7	2.1

Saponification of a Few Aldehyde Derivatives of Ester Character at 25°C in Aqueous Solution; Titrimetric Method (459, 461, 463, 477, 478)

$$(CH_3CO_2)_2CHCH_3 + H_2O \longrightarrow 2CH_3CO_2H + CH_3CHO$$
$$CH_3CO_2CH_2OCH_3 + H_2O \longrightarrow CH_3CO_2H + CH_3OH + CH_2O$$

Ester	Values of k reduced to the basis of one ether-oxygen		
	k_w	k_s	k_a
$(CH_3CO_2)_2CH_2$		0.00402	476
$(CH_3CO_2)_2CHCH_3$		0.00302	48
$CH_3CO_2CH_2OCH_3$		0.0715	34
$CH_3CO_2CH_2OC_2H_5$		0.260	29.5
$(CH_3CO_2)_2CHCH_3$		0.00345	65
$(C_2H_5CO_2)_2CHCH_3$		0.00453	47
$(CH_3CO_2)(C_2H_5CO_2)CHCH_3$		0.00403	52.5
$CH_3CO_2CH(CH_3)(OC_2H_5)$	0.37		
$[(CH_3CO_2)_2CH]_2$	0.000034	0.00410	685

Hydrolysis of Ethers and Ethereal Substances (Alkylacetals, Orthocarboxylic Acid Esters) at 25°C, in Aqueous Solution; Titrimetric Method (457, 458, 460, 461, 462, 470, 476, 478, 487.5)

k_a for ethers is usually immeasurably small.

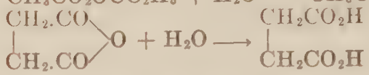
$$CH_2(OCH_3)_2 + H_2O \longrightarrow CH_2O + 2CH_3OH$$
$$CH_2(OCH_3)(OC_2H_5) + H_2O \longrightarrow CH_2O + CH_3OH + C_2H_5OH$$
$$(CH_3)_2C(OC_2H_5)_2 + H_2O \longrightarrow CH_3COCH_3 + 2C_2H_5OH$$
$$HC(OC_2H_5)_3 + H_2O \longrightarrow HCO_2C_2H_5 + 2C_2H_5OH$$
$$C(OC_2H_5)_4 + H_2O \longrightarrow CO(OC_2H_5)_2 + 2C_2H_5OH$$
$$CH_2(OCH_2)_2C(CH_2O)_2CH_2 + H_2O \longrightarrow CH_2(OCH_2)_2C(CH_2OH)_2 + CH_2O$$
$$C_2H_5OC_2H_5 + H_2O \longrightarrow 2C_2H_5OH$$

Ether	Values of k reduced to the basis of one ether-oxygen	
	k_w	k_s
$CH_3C(OC_2H_5)_3$	0.00019	333 000
$HC(OC_2H_5)_3$		23 300
$C(OC_2H_5)_4$	0.000085	3 000
$(CH_3)_2C(OCH_3)_2$		18 500
$(CH_3)_2C(OC_2H_5)_2$		67 500
$CH_3CH(OC_2H_5)_2$		30
$CH_2(OCH_3)_2$		0.0_3765
$CH_2(OC_2H_5)_2$		0.00468
$CH_2(OCH_3)(OC_2H_5)$		0.00272
$C_2H_5OC_2H_5$		0.0_66*
$CH_2(OCH_3)_2$		0.0_376
$CH_2(OC_2H_5)_2$		0.0065
$CH_2(OCH_2CH_2CH_3)_2$		0.0072
$CH_2[OCH(CH_3)_2]_2$		0.0362
$CH_2(OCH_2CH_2CH_2CH_3)_2$		0.00715
$CH_2[OCH_2CH(CH_3)_2]_2$		0.00995
$CH_2[OCH(CH_3)(C_2H_5)]_2$		0.0496
$C[(CH_2O)_2CH_2]_2$		0.0_65
$C[(CH_2O)_2CHCH_3]_2$		0.003
$C[(CH_2O)_2CHC_2H_5]_2$		0.0051
$C[(CH_2O)_2CHCH(CH_3)_2]_2$		0.0022
$C[(CH_2O)_2C(CH_3)_2]_2$		5.2

* This value is extrapolated from 9×10^{-5} at 98°C.

The Constant, k_w, of Hydration of Organic Acid Anhydrides in Aqueous Solution

$$(CH_3CO)_2O + H_2O \longrightarrow 2CH_3CO_2H$$
$$CH_3CO_2OCC_2H_5 + H_2O \longrightarrow CH_3CO_2H + C_2H_5CO_2H$$



$$\begin{matrix} CH_2.CO \\ | \\ CH_2.CO \end{matrix}\!\!>\!O + H_2O \longrightarrow \begin{matrix} CH_2CO_2H \\ | \\ CH_2CO_2H \end{matrix}$$

The anhydrides undergo a rapid saponification in water. Because of the high value of k_w, k_s and k_a are measured only with difficulty.

Conductivity method except for those of (454) which were determined from the kinetics of the simultaneous reaction with iodide-iodate.

Acid anhydride	k_w, 0°	Lit.	k_w, 25°	Lit.
Acetic	0.0336	(525)	0.170	(525)
			0.160	(425)
			0.175	(554)
			0.190	(454)
Propionic	0.0161	(525)	0.0857	(425, 525)
Propionic-acetic			0.121	(525)
n-Butyric	0.0108	(525)	0.0560	
			0.0470	(554)
Isobutyric	0.0105	(525)	0.0523	(525)
Isopropylacetic			0.023↓	
Butyric-isopropylacetic			0.0357	
Methylethylacetic			0.041↓	
Succinic	0.0202	(56, 527)	0.169	(56, 527)
			0.159	(425)
Methylsuccinic			0.227	
Ethylsuccinic			0.154	(525)
asym.-Dimethylsuccinic			0.176	
sym.-Dimethylsuccinic	M. P. = 87°		0.253	(56)
	M. P. = 42°		0.352	
Trimethylsuccinic			0.180	(525)
Tetramethylsuccinic			0.0147	
Maleic	0.287	(56)	1.59	(425)
Glutaric			0.171	(527)
β-Acetylhydroxyglutaric	0.0269	(56)	0.221	(56)
Phthalic			0.607	(425)
Itaconic			0.179	
Citraconic			1.057	
Benzoic			0.0218	(554)
Camphoric			0.0219	

For velocity of reaction in various solvents, its acceleration by acids and the influence of the initial anhydride concentration on k_w, *see* (392).

Alcoholysis of Esters (Interconversion of Ester by Alcohol) in Solutions of ROH

The reaction is accelerated by acids as well as bases:

$$XCOOR' + ROH \longrightarrow XCOOR + R'OH$$

The velocity is proportional to the HCl concentration; k = monomolecular constant referred to [HCl] = 1; t in minutes; θ = 30°C; polarimetric method (135, 136).

Ester	Solvent	10^6k
Menthyl butyrate	Methyl alcohol	6 200
Menthyl crotonate		561
Menthyl hydrocinnamate		5 185
Menthyl cinnamate		397
Ethyl butyrate		90 200
Ethyl crotonate		6 250
Ethyl hydrocinnamate		78 000
Ethyl cinnamate		3 900
Ethyl butyrate	Menthol	58
Methyl butyrate		94.4
Methyl crotonate		9.7

Alcoholysis of Esters.—(*Continued*)

Ester	Solvent	10^6k
Methyl butyrate	Ethyl alcohol	19 800
Methyl crotonate		1 400
Methyl hydrocinnamate		19 100
Methyl cinnamate		1 075

Saponification of Esters of Inorganic Acids, Including Carbonic and Sulfonic Acids

Saponification of Phosphoric Acid Esters in Aqueous Solution

$$R_3PO_4 \xrightarrow{k_1} R_2HPO_4 \xrightarrow{k_2} RH_2PO_4 \xrightarrow{k_3} H_3PO_4$$

Titrimetric method; first-order reaction; *t* in hours; water saponification

R	88°C (107)		
	k_1	k_2	k_3
CH_3	0.0632	0.0036	0.0056
CH_3CH_2	0.0114	0.0015	0.0032
$CH_2{:}CHCH_2$		0.0191	0.00533

R	44°C (107)	
CH_3	$k_3 = 0.000047$	$Q_{10} = 2.96$
C_2H_5	$k_2 = 0.000022$	$Q_{10} = 2.61$
C_2H_5	$k_1 = 0.000115$	$Q_{10} = 2.85$

Values of k_1 at 100°C (153)

Ester	10^4k_1
$(CH_3)_3PO_4$	1314
$(C_2H_5)_3PO_4$	322
$(CH_3)_2(C_2H_5)PO_4$	1110
$(CH_3)_2(CH_3CH_2CH_2)PO_4$	1212
$(C_2H_5)_2(CH_3CH_2CH_2)PO_4$	366

Alkaline saponification of phosphoric acid esters; second-order reaction; units: hours and M/l (107)

$(C_2H_5)_3PO_4$: k_1, 13° = 0.011; k_1, 88° = 3.28. k_1 is measurable; k_2 and k_3 are immeasurably slow.

Saponification of Chlorides and Nitrates; Water Saponification Not Appreciably Accelerated by Acids

Titrimetric method; first-order *k*; *t* in minutes; solvent, equal volumes of H_2O and 95.4% alcohol (388, 389)

$C_6H_5CH_2Cl$, 10^4k	1.1(30°)	3.2(40°)	157.0(83°)
$C_6H_4(CH_3)(CH_2Cl)$	*o-*	*m-*	*p-*
10^3k at 30°	0.55	0.144	1.04
k at 83°	0.077	0.0221	0.163
$C_6H_4(Cl)(CH_2Cl)$, *k* at 83°	0.0052	0.00368	0.0088
$C_6H_4(NO_2)(CH_2Cl)$, *k* at 83°	0.00130	0.00140	0.00115

1-Monochlorohydrin, $CH_2ClCHOHCH_2OH$, in aqueous soln.; $10^5k = 9$ at 100°C.

Ethyl nitrate, $C_2H_5ONO_2$, in equal volumes of H_2O and acetone; $10^6k = 8.3$ at 64°C.

Saponification of Sulfonic Acid Esters in Aqueous Solution

$$C_6H_5SO_2OCH_3 + H_2O \xrightarrow{k} C_6H_5SO_2O^- + H^+ + CH_3OH$$

Titrimetric method; $k = k_w + [H^+]k_s + [OH^-]k_a$; units: minutes and M/l; $\theta = 25°C$ (408, 542)

$[H^+]k_s$ even in rather strongly acid solution is vanishingly small in comparison with the constant, k_w, of water saponification.

$$k_w = 0.0007015;\ k_a = 0.05275$$

In the presence of halogen ion, X^-, the accompanying reaction:

$$C_6H_5SO_2OCH_3 + X^- \xrightarrow{k_0} C_6H_5SO_2O^- + CH_3X$$

also proceeds according to:

$$\frac{dx}{dt} = k_0[X^-](a - x)$$

X^-	Cl^-	Br^-	I^-
k_0, 25°C	0.00139	0.00513	0.0398

In the presence of alcohol, *cf.* (408.5), the following proceeds as a further accompanying reaction:

$$C_6H_5SO_2OCH_3 + C_2H_5OH \longrightarrow C_6H_5SO_2O^- + H^+ + CH_3OC_2H_5$$

Saponification of Sulfuric Acid Esters

$$R_2SO_4 + H_2O \longrightarrow RSO_4^- + H^+ + ROH$$
$$RSO_4^- + H_2O \longrightarrow SO_4^{--} + H^+ + ROH$$

The first reaction follows the same law as for the saponification of sulfonic acid esters (301.5).

In aqueous solution at 60°C, with units of M/l and hours, k_a = 0.00209 for alkaline saponification according to the second stage of saponification (340.5).

Saponification of Carbonic Acid Esters in Aqueous Solution

$$R_2CO_3 + H_2O \longrightarrow CO_2 + 2ROH$$

Titrimetric method; units: minutes and M/l; $\theta = 25°C$ (452, 458); constant for alkaline saponification

R	CH_3	C_2H_5
k_a	7.0	1.6

k_s and k_w are immeasurably small.

Esterification

$$C_6H_5CO_2H + C_2H_5OH \longrightarrow C_6H_5CO_2C_2H_5 + H_2O$$

The velocity of esterification is retarded by water (220, 542.5).

Esterification in Ethyl Alcohol with HCl as Catalyst at 25°C

First-order *k* for minutes; c = concentration of HCl in M/l; w = concentration of H_2O in M/l; titrimetric method (287, 290, 292, 293).

Benzoic acid

$$\frac{2.303}{60k} = 5.78 + \frac{13.24}{c} + \left(-35.36 + \frac{59.26}{c} - \frac{4.778}{c^2} + \frac{1.707}{c^3}\right)(w - 0.013) + \left(16.98 - \frac{24.80}{c} + \frac{38.35}{c^2} - \frac{3.679}{c^3}\right)(w - 0.013)^2$$

c = 0.15 − 0.8; w = 0.03 − 2.26

Trichloroacetic acid

$$\frac{2.303}{60k} = 6.554 + \frac{4.850}{c} + \frac{0.0985}{c^2} + \left(-40.15 + \frac{35.39}{c} - \frac{0.9550}{c^2}\right)(w - 0.013) + \left(16.90 + \frac{12.98}{c} - \frac{1.259}{c^2}\right)(w - 0.013)^2$$

c = 0.16 − 0.67; w = 0.04 − 1.3

Tannic acid

$$\frac{2.303}{60k} = -3.33 + \frac{49.07}{c} - \frac{2.916}{c^2} + \left(61.1 - \frac{23.40}{c} + \frac{25.02}{c^2}\right)(w - 0.013) + \left(-276.6 + \frac{260.6}{c} - \frac{10.02}{c^2}\right)(w - 0.013)^2$$

c = 0.16 − 0.67; w = 0.04 − 1.3

For dibasic acids, the first-order *k* is calculated on the equivalent basis.

Succinic acid

$$\frac{2.303}{60k} = 0.0758 + \frac{0.19146}{c} - \frac{0.0053507}{c^2} + \frac{0.000045457}{c^3} + \left(-1.0875 + \frac{0.73858}{c} + \frac{0.085448}{c^2} - \frac{0.00075172}{c^3}\right)w + \left(-0.0327 + \frac{0.50665}{c} - \frac{0.028853}{c^2} + \frac{0.00025145}{c^3}\right)w^2$$

c = 0.01 − 0.67; w = 0.002 − 1.4

Fumaric acid

$$\frac{60k}{2.303} = 0.869 + \frac{1.074}{c} - \frac{0.01946}{c^2} + \left(-4.009 + \frac{2.893}{c} + \frac{0.8231}{c^2}\right)w + \left(-1.187 + \frac{3.425}{c} + \frac{0.1134}{c^2}\right)w^2$$

c = 0.16 − 0.66; w = 0.002 − 1.4

Tartaric acid

$$\frac{2.303}{60k} = 0.446 + \frac{0.4999}{c} - \frac{0.006107}{c^2} + \left(-1.598 + \frac{1.292}{c} + \frac{0.3286}{c^2}\right)w + \left(-2.069 + \frac{2.818}{c} - \frac{0.09158}{c^2}\right)w^2$$

c = 0.16 − 0.67; w = 0.002 − 1.4

Esterification in Glycerol with HCl as Catalyst at 25°C

Benzoic acid

$$\frac{2.303c}{60k} = 21.74 + 140.2w - 65.32w^{3/2}$$

$$c = 0.08 - 0.24;\ w = 0.03 - 2.0$$

n-Butyric acid

$$\frac{2.303c}{60k} = 0.6072 + 0.5811w + 0.07628w^{3/2}$$

$$c = 0.04 - 0.2;\ w = 0.03 - 1.35$$

Esterification in Ethyl Alcohol at 25°C without Catalyst

a = concentration of acid (in equivalents).

$$k_2 = \frac{1}{ta} \times \frac{x}{(a - x)};\ \text{bimolecular constant}$$

$$k_{\frac{3}{2}} = \frac{2}{t}\left(\frac{1}{\sqrt{a - x}} - \frac{1}{\sqrt{a}}\right);\ \text{sesquimolecular constant}$$

Acid	10^5k_2	$10^5k_{\frac{3}{2}}$	a	w
Mandelic	0.8		0.4 – 0.7	0.03 – 0.1
Trichloroacetic	11.0		0.14 – 0.57	0.1 – 0.2
Malic		0.30	0.14 – 0.4	0.05
Succinic		0.18	0.1 – 0.4	0.05
Tartaric		0.43	0.1 – 0.4	0.02
		0.17	0.1 – 0.4	1.40

For the esterification of HCl by C_2H_5OH, *see* (288, 289, 296).

THE CATALYTIC ESTERIFICATION OF VARIOUS ORGANIC ACIDS IN CH_3OH

Titrimetric method; *t* in hours; k_s = monomolecular constant referred to [HCl] = 1(503, 504, 504.5)

Acid	k_s, 15°	k_s, 20°
Formic, HCO_2H	2568	
Acetic, CH_3CO_2H	239	
Propionic, $CH_3CH_2CO_2H$	211.7	
n-Butyric, $CH_3(CH_2)_2CO_2H$	115.2	
n-Valeric, $CH_3(CH_2)_3CO_2H$	123.2	
Caproic, $CH_3(CH_2)_4CO_2H$	118.7	
n-Heptylic, $CH_3(CH_2)_5CO_2H$	120.9	
Caprylic, $CH_3(CH_2)_6CO_2H$	125.8	
n-Nonylic, $CH_3(CH_2)_7CO_2H$	123.5	
Capric, $CH_3(CH_2)_8CO_2H$	119.3	
Lauric, $CH_3(CH_2)_{10}CO_2H$	121.9	
Myristic, $CH_3(CH_2)_{12}CO_2H$	120.9	
Palmitic, $CH_3(CH_2)_{14}CO_2H$	114.4	
Stearic, $CH_3(CH_2)_{16}CO_2H$	123.7	
Cinnamic, $C_6H_5CH:CHCO_2H$	11.07	
β-Ethylacrylic, $C_2H_5CH:CHCO_2H$	17.18	
Allylacetic, $CH_2:CHCH_2CH_2CO_2H$	45.92	
Phenylisocrotonic, $C_6H_5CH:CHCH_2CO_2H$	81.8	
Ethylidenepropionic, $CH_3CH:CHCH_2CO_2H$	85.4	
Cyclohexanecarboxylic, $C_6H_{11}CO_2H$	19.5	
Benzoic, $C_6H_5CO_2H$	0.251	
Phenylacetic, $C_6H_5CH_2CO_2H$	50.2	
β-Phenylpropionic, $C_6H_5(CH_2)_2CO_2H$	46.8	
γ-Phenyl-*n*-butyric, $C_6H_5(CH_2)_3CO_2H$	56.9	
δ-Phenyl-*n*-valeric, $C_6H_5(CH_2)_4CO_2H$	39.2	
Furylpropionic, $OCH:CHCH:C\text{-}(CH_2)_2CO_2H$	43.5	
α-Phenylpropionic, $CH_3CH(C_6H_5)CO_2H$	9.67	
α-Phenylbenzylacetic, $C_6H_5CH_2CH(C_6H_5)\text{-}CO_2H$	3.59	
Undecylenic, $CH_2:CH(CH_2)_8CO_2H$	53.0	
Oleic, $CH_3(CH_2)_7CH:CH(CH_2)_7CO_2H$	54.4	
Elaidic, $CH_3(CH_2)_7CH:CH(CH_2)_7CO_2H$	54.4	
Erucic, $CH_3(CH_2)_7CH:CH(CH_2)_{11}CO_2H$	51.2	
Brassidic, $CH_3(CH_2)_7CH:CH(CH_2)_{11}CO_2H$	51.8	
Phenyl-*β*-*γ*-crotonic, $C_6H_5CH:CHCH_2CO_2H$	85.4	
Allylacetic, $CH_2:CH(CH_2)_2CO_2H$	45.1	
Hydrosorbic, $CH_3CH_2CH:CHCH_2CO_2H$	69.6	
Phenylpropylideneacetic, $C_6H_5(CH_2)_2\text{-}CH:CHCO_2H$	1.328	
Phenylethylidenepropionic, $C_6H_5CH_2CH:CH\text{-}CH_2CO_2H$	81.8	
Cinnamenylacetic, $C_6H_5CH:CHCH_2CO_2H$	48.4	
Cinnamalacetic, $C_6H_5CH:CHCH:CHCO_2H$	0.732	
Sorbic, $CH_3CH:CHCH:CHCO_2H$	0.737	
α, *β*-Oleic, $CH_3(CH_2)_{14}CH:CHCO_2H$	1.311	
Allocinnamic, $C_6H_5CH:CHCO_2H$	0.882	
Tetrolic, $CH_3C\vdots CCO_2H$	1.274	
Phenylacetic, $C_6H_5CH_2CO_2H$	53.80	71.10
Chloroacetic, CH_2ClCO_2H	37.0	56.2
Bromoacetic, CH_2BrCO_2H	38.7	
Iodoacetic, CH_2ICO_2H	30.4	
Cyanoacetic, $CH_2(CN)CO_2H$	3.4	
Phenoxyacetic, $CH_2(OC_6H_5)CO_2H$	40.1	
Dichloroacetic, $CHCl_2COH$		6.29
Trichloroacetic, $CCl_3CO_2H_2$	0.969	
Benzoic, $C_6H_5CO_2H$	0.238	0.437
o-Toluic, $CH_3C_6H_4CO_2H$	0.092	
o-Ethylbenzoic, $C_2H_5C_6H_4CO_2H$	0.056	0.092
o-Propylbenzoic, $C_3H_7C_6H_4CO_2H$	0.049	
o-Diphenylcarboxylic, $C_6H_5C_6H_4CO_2H$	0.051	
o-Salicylic, $C_6H_4(OH)CO_2H$	0.0129	0.0235
o-Phenoxybenzoic, $C_6H_4(OC_6H_5)CO_2H$	0.471	
Acetophenone-*o*-carboxylic, $CH_3COC_6H_4CO_2H$	7.69	
o-Chlorobenzoic, $C_6H_4(Cl)CO_2H$	0.105	
o-Bromobenzoic, $C_6H_4(Br)CO_2H$	0.085	0.123
o-Iodobenzoic, $C_6H_4(I)CO_2H$	0.0625	0.0936
o-Nitrobenzoic, $C_6H_4(NO_2)CO_2H$	0.0088	
o-Benzoylbenzoic, $C_6H_5COC_6H_4CO_2H$		0.244
o-Naphthoylbenzoic, $C_{10}H_7COC_6H_4CO_2H$		0.0897

Catalytic Esterification in Absolute CH_3OH (Dehydrated by Metallic Ca)

Titrimetric method; k_s monomolecular constant referred to [HCl] = 1; *t* in hours; *θ* = 25°C; values of k_s decrease; initial value of k_s given (227).

Acid	k_s
Acetic, CH_3CO_2H	178.7
Phenylacetic, $C_6H_5CH_2CO_2H$	82.12
Diphenylacetic, $(C_6H_5)_2CHCO_2H$	4.66
Triphenylacetic, $(C_6H_5)_3CCO_2H$	0.0116
p-Tolylacetic, $CH_3C_6H_4CH_2CO_2H$	86.41
Phenyl-*p*-tolylacetic, $CH_3C_6H_4CH(C_6H_5)CO_2H$	5.09
Diphenyl-*p*-tolylacetic, $CH_3C_6H_4C(C_6H_5)_2CO_2H$	0.0040
p-Hydroxyphenylacetic, $CH_2(C_6H_4OH)CO_2H$	91.64
p-Hydroxydiphenylacetic, $C_6H_5CH(C_6H_4OH)CO_2H$	4.73
p-Hydroxytriphenylacetic, $(C_6H_5)_2C(C_6H_4OH)CO_2H$	0.0078
Glycolic, $CH_2(OH)CO_2H$	227.1
Mandelic, $C_6H_5CH(OH)CO_2H$	71.34
Benzilic, $(C_6H_5)_2C(OH)CO_2H$	0.407
Chloroacetic, CH_2ClCO_2H	54.24
Phenylchloroacetic, $C_6H_5CHClCO_2H$	10.25

For the influence of degree of dehydration of methyl alcohol on the constant of catalytic esterification, *see* (228). For the retarding effect of small amounts of water, *see* (200, 201, 203, 220). For esterification of mercaptans, *see* (174, 187, 298, 430).

Dynamics of Esterification- and Acetalization-Equilibrium

See the classic work of (37, 226, 259, 304, 356).

DYNAMICS OF ESTER EQUILIBRIUM WITH CONSTANT CONCENTRATION OF WATER AND ALCOHOL

$$\underset{\mathrm{a - x}}{\mathrm{XCO_2H}} + \mathrm{C_2H_5OH} \overset{k_1}{\underset{k_2}{\leftrightarrows}} \underset{\mathrm{x}}{\mathrm{XCO_2C_2H_5}} + \mathrm{H_2O}$$

$$\frac{\mathrm{dx}}{\mathrm{d}t} = k_1(\mathrm{a - x}) - k_2\mathrm{x}$$

$$k_1 + k_2 = \frac{1}{t}\log_e\frac{\xi}{\xi - \mathrm{x}};\ \xi = \mathrm{x\ for}\ t = \infty;\ \frac{k_1}{k_2} = \frac{\xi}{\mathrm{a} - \xi}$$

Titrimetric method; t in minutes; $\theta = 24.8°\mathrm{C}$; catalyst, 0.026N HCl (300)

% C_2H_5OH	Substrate	$10^5(k_1 + k_2)$	10^5k_1	10^5k_2
56.5	CH_3CO_2H..........	32.70	19.80	12.90
56.7	$CH_3CO_2C_2H_5$.......	32.93	19.94	12.99
56.5	HCO_2H............	360.9	175.5	185.4
56.5	$HCO_2C_2H_5$.........	358.1	173.9	184.2
50.2	HCO_2H............	370.8	159.4	211.4
50.5	$HCO_2C_2H_5$.........	368.5	158.4	210.1
43.9	HCO_2H............	393.8	153.6	240.2
43.9	$HCO_2C_2H_5$.........	393.8	153.6	240.2

EFFECT OF LENGTHENING THE CARBON CHAIN

$$\mathrm{(CH_2)_n(CO_2CH_3)_2 + H_2O} \overset{2k_1}{\underset{k_2}{\leftrightarrows}} \mathrm{(CH_2)_n(CO_2H)(CO_2CH_3) + CH_3OH}$$

$$\mathrm{(CH_2)_n(CO_2H)(CO_2CH_3) + H_2O} \overset{k_1}{\underset{2k_2}{\leftrightarrows}} \mathrm{(CH_2)_n(CO_2H)_2 + CH_3OH}$$

Titrimetric method; t in hours; $\theta = 25°\mathrm{C}$; catalyst, 0.05N HCl; solvent = 50 Vol. % CH_3OH (397.8)

$$k_1 + k_2 = \frac{1}{t}\log_e\frac{\mathrm{U - u_0}}{\mathrm{U - u}}$$

$\mathrm{u_0, u, U}$ = Titer for time = 0, t, ∞.

$$\left.\begin{array}{l} k_1 = \text{Saponification velocity} \\ k_2 = \text{Esterification velocity} \end{array}\right\} \text{reduced to } N\ \text{HCl.}$$

Methyl ester of:	n	$k_1 + k_2$	k_1	k_2	$k_1:k_2$
Oxalic acid.................	0	0.554	0.308	0.246	1.256
Malonic acid...............	1	0.153	0.051	0.102	0.496
Succinic acid...............	2	0.220	0.065	0.155	0.417
Glutaric acid...............	3	0.546	0.152	0.394	0.386
Adipic acid.................	4	0.618	0.170	0.448	0.380
Pimelic acid................	5	0.626	0.172	0.454	0.379
Suberic acid................	6	0.664	0.178	0.486	0.366
Azelaic acid................	7	0.632	0.169	0.463	0.366
Sebacic acid................	8	0.504	0.112	0.392	0.286
n-Butyric acid.............		0.667	0.186	0.491	0.377

n-Butyric acid is introduced for comparison. In the series of oxalic acid homologues, k_1 and k_2 are at a minimum for malonic acid and at a maximum for suberic acid; *cf.* (453, 469, 472).

DYNAMICS OF ESTER EQUILIBRIUM WITH VARYING CONCENTRATIONS OF WATER AND ALCOHOL

$$\underset{\mathrm{a - x}}{\mathrm{CH_3CO_2C_2H_5}} + \underset{\mathrm{b - x}}{\mathrm{H_2O}} \overset{k_1}{\underset{k_2}{\rightleftarrows}} \underset{\mathrm{x}}{\mathrm{CH_3CO_2H}} + \underset{\mathrm{x}}{\mathrm{C_2H_5OH}}$$

Titrimetric method; units: minutes and M/l; catalyst, HCl; $\theta = 25°\mathrm{C}$ (242)

$$\frac{\mathrm{dx}}{\mathrm{d}t} = k_1(\mathrm{a - x})(\mathrm{b - x}) - k_2\mathrm{x}^2.$$

$$k_1 = \frac{l}{t}\log_e\frac{\mathrm{n - mx}}{\mathrm{n} - 2(1 - K)\mathrm{x}}.$$

$$l = \frac{1}{\sqrt{(\mathrm{a + b})^2 - 4\mathrm{ab}(1 - K)}}.$$

$$\mathrm{m} = \frac{(\mathrm{a + b}) - \sqrt{(\mathrm{a + b})^2 - 4\mathrm{ab}(1 - K)}}{(\mathrm{a + b}) + \sqrt{(\mathrm{a + b})^2 - 4\mathrm{ab}(1 - K)}} \times 2(1 - K).$$

$$\mathrm{n} = (\mathrm{a + b}) - \sqrt{(\mathrm{a + b})^2 - 4\mathrm{ab}(1 - K)}.$$

$K = \frac{k_2}{k_1}$, equilibrium constant.

Determinations with ester concentration, a, = 0.470.

[HCl]	K	10^6k_1:[HCl]
0.01	3.39	116.7
0.03	3.87	114.7
0.05	3.50	114.5
0.07	3.89	113.9
0.10	3.87	114.6
0.15	3.61	115.8
0.20	4.01	116.3
0.30	4.00	117.8
0.50	3.93	120.1
0.70	3.68	122.9
1.00	3.35	125.2
1.50		130.8

Acid Hydrolysis of Methyl Acetate in Water-Acetone at 25°C (102)

$$\underset{\mathrm{a - x}}{\mathrm{CH_3CO_2CH_3}} + \underset{\mathrm{w - x}}{\mathrm{H_2O}} \overset{k_1}{\underset{k_2}{\leftrightarrows}} \underset{\mathrm{x}}{\mathrm{CH_3CO_2H}} + \underset{\mathrm{x}}{\mathrm{CH_3OH}}$$

$$\frac{\mathrm{dx}}{\mathrm{d}t} = k_1(\mathrm{a - x})(\mathrm{w - x}) - k_2\mathrm{x}^2.$$

$$k_1 = \frac{1}{t\mathrm{A}}\log_e\frac{\mathrm{A + y} + 2(K - 1)\mathrm{x}}{\mathrm{A - y} - 2(K - 1)\mathrm{x}} \times \frac{\mathrm{A - y}}{\mathrm{A + y}}.$$

$\mathrm{y = a + w}$.

$\mathrm{A} = \sqrt{(\mathrm{a + w})^2 + 4(K - 1)\mathrm{aw}}$.

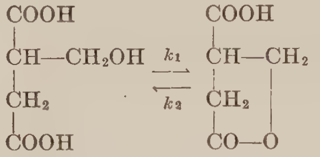
$K = \frac{k_2}{k_1}$, equilibrium constant; a = 0.6267; c = acetone, M/l.

Titrimetric method; units: M/l and minutes; catalyst, 0.5N HCl

Vol. % $(CH_3)_2CO$	c	w	K	10^5k_1
0	0	52.32	5.40	6.36
20	2.665	42.26	5.10	6.98
40	5.39	32.08	4.39	7.88
60	8.10	21.23	4.47	8.89
70	9.42	15.72	4.51	10.50
80	10.66	10.20	5.14	17.04
90	11.84	4.752	8.97	45.05

For acid hydrolysis of ethyl formate in water-acetone, *see* (332)

DYNAMICS OF HYDROLYSIS OF γ-LACTONES IN AQUEOUS SOLUTION



Itamalic acid — Paraconic acid

a − x — x

$$\frac{\mathrm{dx}}{\mathrm{d}t} = k_1(\mathrm{a - x}) - k_2\mathrm{x}.$$

$$t = \infty;\ \mathrm{x} = \xi = \frac{\mathrm{a}k_1}{k_1 + k_2}.$$

$$k_1 + k_2 = \frac{1}{t}\log_e\frac{\xi}{\xi - \mathrm{x}}.$$

$K = \frac{k_1}{k_2} = 1.10$, equilibrium constant.

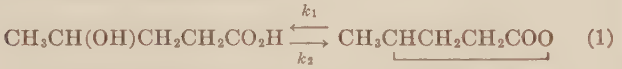
HYDROLYSIS OF γ-LACTONES—(*Continued*)

Titrimetric method; units: hours and M/l; catalyst, HNO_3; $a = 0.025$; $\theta = 25°C$ (^{268})

N HNO_3,	$(k_1 + k_2)$*	$(k_1 + k_2)$†
0.0125	0.014	0.014
0.0250	0.031	0.0305

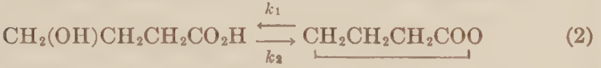
$$k_1 = 0.58\,[H^+],\ k_2 = 0.53[H^+],\ K = \frac{0.58}{0.53} = 1.1.$$

* From lactonization of itamalic acid.
† From hydrolysis of paraconic acid.



$$CH_3CH(OH)CH_2CH_2CO_2H \underset{k_2}{\overset{k_1}{\leftrightarrows}} CH_3\underline{CHCH_2CH_2COO} \qquad (1)$$

γ-Hydroxyvaleric acid γ-Valerolactone



$$CH_2(OH)CH_2CH_2CO_2H \underset{k_2}{\overset{k_1}{\leftrightarrows}} \underline{CH_2CH_2CH_2COO} \qquad (2)$$

γ-Hydroxybutyric acid γ-Butyrolactone
(a − x) x

Titrimetric or conductivity method; units: minutes and M/l; $\theta = 25°C$ (**195, 246, 282, 291, 509**)

C = concentration of catalyst.

$k_1 = [H^+]k_l,\ k_2 = [H^+]k_s,\ [H^+] = C.$

$K = \dfrac{k_l}{k_s} = \dfrac{[\text{Lactone}]}{[\text{Hydroxy acid}]}$, equilibrium constant.

K for butyrolactone = 2.683 (^{246}); = 2.66 (^{291}); mean = 2.67.

K for valerolactone = 13.71 (^{246}); = 13.86 and 13.7 (^{291}); = 11.5 (^{509}); = 15.7 (^{195}); mean = 13.8.

Reaction without Catalyst

If α is the degree of dissociation of the hydroxy acid, κ its dissociation constant, then, under the assumption that only the *undissociated* hydroxy acid is converted to lactone:

$$\frac{dx}{dt} = k_l\alpha(1-\alpha)(a-x)^2 - k_s\alpha(a-x)x$$

$$\alpha^2(a-x) = (1-\alpha)\kappa;\ \text{or, since } 1 \gg \alpha,\ \alpha = \sqrt{\frac{\kappa}{a-x}}$$

$$k_l + k_s = \frac{1}{t\sqrt{\dfrac{\kappa a}{1+K}}} \times \log_e \frac{\left(\sqrt{\dfrac{a}{1+K}} + \sqrt{a-x}\right)\left(\sqrt{\dfrac{a}{1+K}} - \sqrt{a}\right)}{\left(\sqrt{\dfrac{a}{1+K}} - \sqrt{a-x}\right)\left(\sqrt{\dfrac{a}{1+K}} + \sqrt{a}\right)}$$

$\kappa = 1.94 \times 10^{-5}$ for γ-hydroxybutyric acid; $\kappa = 0.202 \times 10^{-5}$ for γ-hydroxyvaleric acid.

Reaction 1 (^{291})

a	0.04295	0.0617	0.1297	0.1429	0.1789
$k_l + k_s$	0.153	0.148	0.146	0.144	0.144

Mean: 0.148.

Reaction 2 (^{291}): $k_l + k_s = 0.0509$.

Reaction with HCl (HNO_3) as Catalyst

$$\frac{dx}{dt} = k_lC\,(a-x) - k_sCx$$

$$k_l + k_s = \frac{1}{tC}\log_e\frac{\xi}{\xi - x};\ x = \xi \text{ for } t = \infty$$

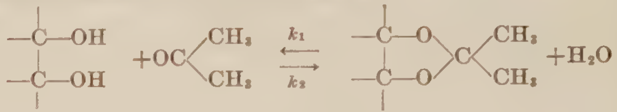
Means of all determinations

Reaction	$k_l + k_s$	K	k_l	k_s
1	0.156	13.8	0.145	0.0106
2	0.0506	2.67	0.0368	0.0138

For the effect of temperature, the use of activity in place of concentration, the effect of electrolytes (KCl, LiCl) and of nonelectrolytes (sugar) on the velocity, *see* the original literature.

DYNAMICS OF ACETALIZATION EQUILIBRIUM

Acetalization of diols by acetone at constant concentrations of water and acetone with HCl as catalyst:

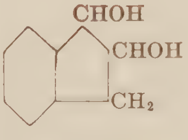


$$K = \frac{k_1}{k_2}$$

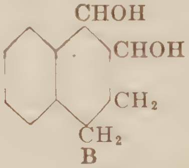
$$k_1 + k_2 = \frac{1}{t}\log_e\frac{\xi}{\xi - x};\ x = \xi \text{ for } t = \infty$$

Titrimetric method; units: hours and M/l (^{247})

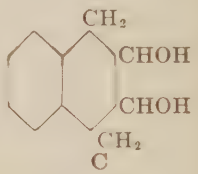
$$\log_e k = -\frac{E}{RT} + J$$



A: *cis*-1, 2-Hydrindenediol



B



C

Tetrahydronaphthalenediol

$C_6H_5CH(OH)CH(OH)C_6H_5$, Hydrobenzoin
D: *dl*-Hydrobenzoin (inactive analog of antitartaric acid)
E: *r*-Hydrobenzoin (inactive analog of racemic acid)

Solvent and catalyst:	$[H_2O]:[(CH_3)_2CO]$	[HCl]
For the three cyclic diols	2.310	0.00018
For the two hydrobenzoins	0.9809	0.0106

Diol:	A	B	C	D	E
k_1, 24.9°*	0.0138	0.00644	0.00144	0.00263	0.0230
k_1, 44.5°	0.0736	0.0396	0.0123	0.0212	0.130
k_2, 24.9°*	0.00160	0.00122	0.000522	0.00598	0.00269
k_2, 44.5°	0.0150	0.0125	0.00712	0.0793	0.0304
k_1, E	16 100	17 500	20 600	20 200	16 700
k_1, J	22.7	24.3	28.1	27.9	24.3
k_2, E	21 600	22 500	25 100	23 900	21 900
k_2, J	29.7	31.0	34.6	35.0	30.8
k_1, Q_{10}†	2.23	2.36	2.76	2.69	2.26
k_2, Q_{10}†	2.90	3.06	3.49	3.27	2.94

* For D and E the temperature is 25.0°C.
† Q_{10} holds for the interval 25–35°C.

On account of the equilibrium position, the measurements of $(k_1 + k_2)$ for A, B and E were made starting from the diol; for C and D from the acetonal. For the dynamics of acetalization of CH_2O with various alcohols, *see* (^{145}).

Hydrolysis of Nitriles, Acid Amides and the Inverse Reactions

HYDROLYSIS OF ACETAMIDE IN AQUEOUS SOLUTION

$$\underset{(a-x)}{CH_3CONH_2} + H_2O \longrightarrow CH_3CO_2H + NH_3$$

$$\frac{dx}{dt} = k_s[H^+](a-x) + k_a[OH^-](a-x)$$

Titrimetric and gas-volumetric methods; t in minutes ($^{173, 402}$); *cf.* ($^{13, 129, 295, 395, 414}$)

Constant	Value	°C	Lit.
k_a	0.0024	25	(^{402})
k_s	0.000377	25	
k_s*	0.00777	49.3	(^{173})
k_s*	0.0223	64.3	

* E = 15 400.

For dynamics of equilibrium in glacial acetic acid solution, *see* (^{387}).

HYDROLYSIS OF ACETANILIDE IN AQUEOUS SOLUTION

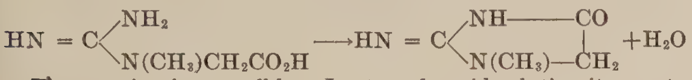
$$\underset{(a-x)}{CH_3CONHC_6H_5} + H_2O \longrightarrow CH_3CO_2H + C_6H_5NH_2$$

$$\frac{dx}{dt} = k_s[H^+](a-x) + k_a[OH^-](a-x)$$

Titrimetric method; t in hours; $\theta = 100°C$; $k_s = 8.4 \pm 0.1$ (358); $k_a = 3.2$ (137)

In NaOH and HCl solution the reaction runs to completion; in CH_3CO_2H solution it is perceptibly reversible.

CONVERSION OF CREATINE INTO CREATININE IN AQUEOUS SOLUTION



$$HN=C\left\langle\begin{matrix}NH_2\\N(CH_3)CH_2CO_2H\end{matrix}\right. \longrightarrow HN=C\left\langle\begin{matrix}NH—CO\\N(CH_3)—CH_2\end{matrix}\right. + H_2O$$

The reaction is reversible. In strongly acid solution it runs to completion.

Titrimetric method; first-order k for t in minutes; if $[HCl] \gg a$, $[H^+]$ = constant; a = initial concentration of creatine in M/l (161).

°C	[HCl]	a	10^2k	Q_{10}
25	0.38	0.0075	0.00340	
57	0.38	0.0300	0.0777	2.66
78	0.38	0.0075	0.494	2.41
100	0.38	0.0075	2.816	2.21
100	0.19	0.00367	1.367	
78	0.19	0.00447	0.256	2.14
78	0.76	0.0300	1.235	
78	0.76	0.0150	1.256	

E = 20 000 as average independent of [HCl].

KINETICS OF ANILIDE FORMATION FROM ORGANIC ACIDS IN ANILINE (RESP. *o*-TOLUIDINE) AS SOLVENT

$$XCO_2H + C_6H_5NH_2 \longrightarrow XCONHC_6H_5 + H_2O$$

Titrimetric method; units: hours and M/l; $\theta = 100°C$ (206, 221)

With respect to XCO_2H, the reaction is of second-order (constant, k_2); in the presence of picric acid (concn., c) as catalyst, it is of first-order (constant, k_1) and the velocity is approximately proportional to c.

Solvent, XCO_2H	Aniline, k_2	*o*-Toluidine, k_2	Aniline, c = 0.5, k_1
CH_3CO_2H	0.039	0.013	0.070
$CH_3CH_2CO_2H$	0.021		0.043
$CH_3(CH_2)_2CO_2H$	0.0126	0.0050	0.026
$(CH_3)_2CHCO_2H$	0.0052	0.0023	0.011

HCO_2H in Aniline, k_2	1.77(45°)	3.30(55°)
HCO_2H in *o*-Toluidine, k_2	0.87(45°)	1.44(55°)

HYDROLYSIS OF UREA IN AQUEOUS AND ACID SOLUTIONS

$$CO(NH_2)_2 + 2H_2O \longrightarrow CO(ONH_4)_2$$

Titrimetric method; first-order k for t in minutes; $\theta = 100°C$ (176, 410)

N = normality of acid, HCl (176); HNO_3 (410)

N	$10^5k(HNO_3)$	$10^5k(HCl)$
2	168	
1	201	133
0.5	246	177
0.25	255	207
0.125	267	232
0.0625	306	232

Effect of temperature on reaction mixture, $0.5N$ $CO(NH_2)_2$ + $0.5N$ HNO_3

°C	100	89	80	70
10^5k	235	53.0	21.4	3.5

HYDROLYSIS OF CYANAMIDE IN AQUEOUS SOLUTION

$$CNNH_2 + H_2O \xrightarrow{k} CO(NH_2)_2 \qquad (1)$$

$$2CNNH_2 \longrightarrow (CNNH_2)_2 \qquad (2)$$

Titrimetric method; monomolecular k [reaction (1)] for t in minutes in 0.06 molal H_2SO_4; $k = 0.00189$; $\theta = 50°C$ (251)

In alkaline solution in addition to reaction (1) apparently catalyzed by OH^-, reaction (2) also proceeds; t in hours; N_c, (resp. N_u, N_d) = % N of cyanamide (resp. urea, dicyandiamide).

NaOH, N / t	0.01			0.1			1.0		
	N_c	N_u	N_d	N_c	N_u	N_d	N_c	N_u	N_d
1	92.1	2.9	5.0	69.6	3.2	17.2	94.0	5.0	1.0
2	90.4	3.3	6.3	55.6	3.8	40.6	92.3	7.0	0.7
3	85.5	3.3	10.9	44.4	4.1	51.5	89.3	8.3	2.4
20	47.2	4.9	47.9	14.1	10.1	75.8	62.7	34.4	2.9

For both reactions, *see also* (223, 373).

ACID HYDROLYSIS OF NITRILES IN AQUEOUS ALCOHOL

$$RCN + H_2O \xrightarrow{k} RCONH_2 \qquad \text{(measurable)}$$

$$RCONH_2 + H_2O + H^+ \longrightarrow RCO_2H + NH_4^+ \qquad \text{(rapid)}$$

$$\underset{a-x}{RCN} + \underset{b-x}{2H_2O} + H^+ \xrightarrow{k} RCO_2H + NH_4^+ \text{ (net reaction)}$$

$$\frac{dx}{dt} = k(a-x)(b-x)$$

Volumetric method; units: minutes and M/l; solvent 46.2% C_2H_5OH (27.3M H_2O + 13.2M C_2H_5OH/l); catalyst, HCl; k, corrected for the formation of C_2H_5Cl (297).

$$A' = \frac{T_1T_2\,(\log_{10} k_1 - \log_{10} k_2)}{T_1 - T_2}$$

Nitrile	10^3k		
	74°	110°	A′
CH_3CN	0.0242	0.76	5530
CH_3CH_2CN	0.0363	1.17	5640
$CH_3(CH_2)_2CN$		0.715	
$CH_3(CH_2)_3CN$	0.0224	0.66	5430
CH_3OCH_2CN	0.0595		
$CH_3CH_2OCH_2CN$	0.0550	1.44	5260
$CH_3(CH_2)_2OCH_2CN$		1.52	
$CH_3O(CH_2)_2CN$		0.62	6010
$CH_3CH_2O(CH_2)_2CN$	0.0161		
$CH_3O(CH_2)_3CN$		0.77	
$CH_3CH_2O(CH_2)_3CN$	0.0239		

For the alkaline saponification of nitriles, *see* (402).

Hydrolysis of Diazo Compounds

KINETICS OF DECOMPOSITION OF DIAZOACETIC ESTER IN AQUEOUS SOLUTION

$$CHN_2CO_2C_2H_5 + H_2O \longrightarrow CH_2(OH)CO_2C_2H_5 + N_2$$

Catalysis of Reaction by Acids

Gas-volumetric method; monomolecular k for t in minutes; θ = 25°C; c = concentration of catalyst (67)

Catalyst	10^3c	$10^3[H^+]$	$100k$	$k:[H^+]$
HNO_3	1.82	1.82	7.03	38.7
	0.909	0.909	3.51	38.6
	0.909	0.909	3.37	37.1
$C_6H_2(OH)(1)(NO_2)_3(2, 4, 6)$	0.909	0.909	3.63	39.9
	0.909	0.909	3.45	38.0
	0.364	0.364	1.37	37.6
	0.364	0.364	1.42	39.0
$C_6H_4(NO_2)(3)(CO_2H)(1)$	9.90	1.68	6.40	38.1
	9.90	1.68	6.25	37.2
CH_3CO_2H	18.2	5.63	2.20	39.1
	18.2	5.63	2.14	38.0

$$\frac{d[N_2]}{dt} = 38.5[H^+][CHN_2CO_2C_2H_5]$$

Effect of temperature

$$\log_e \frac{k_1}{k_2} = A\frac{T_1 - T_2}{T_1T_2};\ A = 8869;\ k_s = k:[H^+]$$

°C	15	25	35	45
k_s, obs	13.7	38.5	102	246
k_s, calc	(13.7)	(38.5)	104	250
Q_{10}		2.80	2.64	2.43

For adiabatic kinetics of the reaction, *see* (72, 326). For kinetics of the reactions:

$$CHN_2CO_2C_2H_5 + H^+ + Cl^- \longrightarrow CH_2ClCO_2C_2H_5 + N_2$$

$$CHN_2CO_2C_2H_5 + C_2H_5OH \longrightarrow CH_2(OC_2H_5)CO_2C_2H_5 + N_2$$

see (81, 183, 375).

Determination of $[H^+]$ in a Solution of $K_2Cr_2O_7$ from the Velocity of Diazoacetic Ester Catalysis at 25°C (495)

$K_2Cr_2O_7$	10^4k, obs.	$10^4[H^+]$, calc.
0.2208	173	4.49
0.1206	117	3.04
0.1012	100	2.60
0.0603	72.2	1.88
0.0483	65.2	1.69
0.0302	48.4	1.27
0.0169	37.8	0.95

For further application of this method, *see* (131, 262, 534).

DECOMPOSITION OF AROMATIC DIAZONIUM SALTS IN AQUEOUS SOLUTION

$$ArN_2Cl + H_2O \longrightarrow ArOH + HCl + N_2$$

Ar = Aryl

Titrimetric and colorimetric methods; monomolecular k for t in minutes, $k' = 0.4343k$; $\theta = 25°C$ (235)

Ar	$10^4k'$
Benzene	6.4–7.2
p-Toluene	0.81
p-Bromobenzene	Very small
Anisole	Very small
Pseudocumene	30–44

The reaction is not influenced by acids.

Methods and units as above (166)

Diazonium chloride of*:	$10^4k'$	$10^4k'$, 50° (extrap.)
Benzene	12.2 (25°)	270
o-Toluene	35 (25°)	770
m-Toluene	37 (25°)	800
p-Toluene	0.81 (25°)	18
Pseudocumene	31 (25°)	680
m-Benzoic acid	12 (25°)	264
p-Benzoic acid	2.7 (25°)	59
o-Anisole	4.0 (80°)	0.11
p-Anisole	4.4 (80°)	0.12
o-Chlorobenzene	0.80 (80°)	0.068
m-Chlorobenzene	11.5 (50°)	
p-Chlorobenzene	5.1 (60°)	1.5
m-Bromobenzene	15.0 (45°)	30
p-Bromobenzene	2.3 (50°)	

* The italicized letters indicate the position of the N_2Cl group in the compound.

The anion of the diazonium salt is without appreciable influence.

Effect of temperature

$C_6H_5N_2Cl$			p-$BrC_6H_4N_2Cl$		
°C	$10^3k'$	Q_{10}	°C	$10^3k'$	Q_{10}
15	0.31		40	0.062	
25	1.22	3.93	50	0.23	3.72
30	2.40	3.87	70	2.8	3.49
A = 11 905			A = 13 634		

Kinetics of Diazotization and Coupling Processes

KINETICS OF DIAZOTIZATION IN AQUEOUS SOLUTION

$$ArNH_3Cl + HNO_2 \longrightarrow ArN_2Cl + 2H_2O$$

The velocity of diazotization is proportional to the concentrations of amine salt and nitrous acid.

Colorimetric method; the velocity was only slightly influenced by excess acid; second-order k; units: minutes and M/l; $\theta = 0°C$ (54, 238); *cf.* (437, 505, 506).

Salt of amine	k (54)	k (238)
$C_6H_5NH_2$	48.3	36
$C_6H_3(CH_3)_2(2, 4)NH_2$	44.3	41
$C_6H_4(CH_3)(2)NH_2$	46.4	
$C_6H_4(CH_3)(4)NH_2$	34.4	38
$C_6H_4(CH_3)(3)NH_2$	68.5	
$C_6H_4Cl(2)NH_2$	241.5	
$C_6H_4Cl(4)NH_2$	76.5	
$C_6H_4Cl(3)NH_2$	67.5	
$C_6H_4Br(2)NH_2$	225.0	
$C_6H_4Br(4)NH_2$	64.5	45
$C_6H_4Br(3)NH_2$	71.0	
$C_6H_4I(2)NH_2$	226.5	
$C_6H_4I(4)NH_2$	75.2	
$C_6H_4I(3)NH_2$	75.7	
$C_6H_4(SO_3H)(2)NH_2$	483.0	
$C_6H_4(SO_3H)(4)NH_2$	123.5	
$C_6H_4(SO_3H)(3)NH_2$	53.5	
$C_6H_4(CO_2H)(2)NH_2$	880.5	
$C_6H_4(CO_2H)(4)NH_2$	160.5	
$C_6H_4(CO_2H)(3)NH_2$	72.5	
$C_6H_4(NO_2)(3)NH_2$	565.0	

KINETICS OF THE COUPLING PROCESS IN AQUEOUS SOLUTION

Gas-volumetric determination of diazonium salt; units: minutes and M/l (208, 209, 211, 212, 214).

Formation of Aminoazo Compounds in Strongly Acid (HCl) Solutions

$$\underbrace{N_2C_6H_4SO_2O}_{(c\ -\ x)} + \underset{(a\ -\ x)}{C_6H_5N(CH_3)_2HCl} \longrightarrow \underset{ppt.}{(CH_3)_2NC_6H_4N_2C_6H_4SO_3H} + \underset{(b\ +\ x)}{HCl}$$

κ = hydrolysis constant of amine salt.

ξ = concn. of free amine.

$$\xi = \kappa\frac{(a - x)}{(b + x)}.$$

The diazonium salt and free amine react, therefore, as follows:

$$\frac{dx}{dt} = k\xi(c - x) = k\kappa\frac{(a - x)(c - x)}{(b + x)}$$

k = bimolecular constant.

Diazonium salt	Salt of amine	°C	$k\kappa$
p-$\underbrace{N_2C_6H_4SO_2O}$	$C_6H_5N(CH_3)_2$	20	0.0053
		25	0.0086
		30	0.0135
	$C_6H_5N(C_2H_5)_2$	20	0.00095
		25	0.00145
		30	0.00246
	$C_6H_5N(CH_2CH_2CH_3)_2$	20	0.00202
		25	0.00365
	m-$CH_3C_6H_4N(CH_3)_2$	20	0.0606
		25	0.0797
	m-$CH_3C_6H_4N(C_2H_5)_2$	20	0.00709
		25	0.0104
	m-$ClC_6H_4N(CH_3)_2$	25	0.0099
	m-$ClC_6H_4N(C_2H_5)_2$	20	0.00147
		25	0.00215

Formation of Aminoazo Compounds.—(*Continued*)

Diazonium salt	Salt of amine	°C	$k\kappa$
m-$C_6H_4(NO_2)N_2NO_3$	$C_6H_5N(CH_3)_2$	20	0.135
	$C_6H_5N(C_2H_5)_2$	20	0.023
p-$C_6H_4(NO_2)N_2NO_3$	$C_6H_5N(C_2H_5)_2$	20	0.022
m-$\underbracket{N_2C_6H_4SO_2O}$	$C_6H_5N(CH_3)_2$	20	0.0054

Formation of Aminoazo Compounds in Solution of Weak Acids (HA)

$$\underset{(c - x)}{\underbracket{N_2C_6H_4SO_2O}} + \underset{(a - x)}{C_6H_5N(CH_3)_2HA} \longrightarrow \underset{\text{ppt.}}{(CH_3)_2NC_6H_4N_2C_6H_4SO_3H} + \underset{(b + x)}{HA}$$

κ = hydrolysis constant of amine salt.
ξ = concn. of free amine.
δ = dissociation constant of acid, HA.

If b is sufficiently great with respect to a (b ⋝ 10a), then

$$[H^+] = \delta \frac{(b + x)}{(a - x)}$$
$$\xi[H^+] = \kappa (a - x)$$
$$\xi = \frac{\kappa}{\delta} \frac{(a - x)^2}{(b + x)}$$

The diazonium salt and the free amine react, therefore, as follows:

$$\frac{dx}{dt} = k\xi(c - x) = k\frac{\kappa}{\delta}\frac{(a - x)^2(c - x)}{(b + x)}$$
$$k\frac{\kappa}{\delta} = C$$

Between C and $k\kappa$ of the preceding tables, the relation $C = \frac{k\kappa}{\delta}$ must, therefore, hold; whereby C may be calculated from $k\kappa$ and δ.

Determinations with p-$\underbracket{N_2C_6H_4SO_2O}$

HA	100δ	Amine	°C	C, obs.	C, calc.
CH_2ClCO_2H	0.155	$C_6H_5N(C_2H_5)_2$	25	1.15	0.94
CH_3CO_2H	0.0018		25	77.7	80.6
			20	49.2	52.8
HCO_2H	0.0214	$C_6H_5N(CH_3)_2$	20	25.8	25.0
		$C_6H_5N(C_2H_5)_2$	20	3.9	4.4
			25	7.0	6.8
$C_2H_5CO_2H$	0.00134		20	61.0	70.9
			25	108.7	108.2
$CH_3CO(CH_2)_2CO_2H$	0.00255		20	38.3	37.7
			25	57.3	57.0
$CH_3CH(OH)CO_2H$	0.0310		20	3.1	3.1
			25	5.0	4.7

Measurements of k were also made in solutions saturated with respect to diazonium salt (c = constant). They yielded the same values for $k\kappa$ and for C.

Formation of Hydroxyazo Compounds in Alkaline Solution

$$\underset{(c - x)}{NaON_2C_6H_4SO_3Na} + \underset{(a - x)}{C_6H_5ONa} \longrightarrow NaOC_6H_4N_2C_6H_4SO_3Na + \underset{(b + x)}{NaOH}$$

κ_1 = hydrolysis constant of phenolate.
κ_2 = hydrolysis constant of diazotate.
ξ = concn. of free phenol.
η = concn. of free diazo acid.

$$\xi = \kappa_1 \frac{(a - x)}{(b + x)};\ \eta = \kappa_2 \frac{(c - x)}{(b + x)}.$$

Free phenol and free diazo acid react, therefore, as follows:

$$\frac{dx}{dt} = k\xi\eta = k\kappa_1\kappa_2 \frac{(a - x)(c - x)}{(b + x)^2}$$

Measurements with sodium *syn*-diazobenzene-*p*-sulfonic acid at 0°C

Hydroxy comp	Phenol	*o*-Cresol	*m*-Cresol
$k\kappa_1\kappa_2$	0.0008	0.01	0.01

Formation of Hydroxyazo Compounds.—(*Continued*)

Hydroxy comp	β-Naphthol	Thymol	Resorcinol
$k\kappa_1\kappa_2$	0.03	0.11	0.2

Measurements with sodium diazobenzene at 0°C

Hydroxy comp	β-Naphthol	*m*-Cresol
$k\kappa_1\kappa_2$	2.3	0.95

Indirect Ether and Ester Formation

FORMATION OF ETHER FROM RBR IN C_2H_5OH AS SOLVENT

$$RBr + C_2H_5OH \longrightarrow ROC_2H_5 + HBr$$

Volumetric method; first-order k for t in minutes, $k' = 0.4343k$; C_2H_5OH(abs.) = commercial abs. alcohol (1% H_2O); C_2H_5OH (CaO) = alcohol dried over CaO (231). $10^5k'$ in C_2H_5OH(abs.) as solvent.

RBr	25°	45°	65°	65°*
$C_6H_5CH_2Br$	1.44	13.4	101	86
$C_6H_5CH_2Cl$			4.33	3.44
$CH_2{:}CHCH_2Br$	0.30	2.93	24.0	21.6
C_2H_5Br			2.39	1.73

* C_2H_5OH(CaO) as solvent.

In an inert solvent (*e.g.*, CH_3COCH_3) the reaction with respect to RBr and C_2H_5OH is of the first-order, the total, therefore, of the second order.

A′ = 4600 for benzyl bromide; = 4750 for allyl bromide

ETHER FORMATION FROM ESTERS OF SULFONIC ACID IN ALCOHOLS (ROH) AS SOLVENT

$$C_6H_5SO_3C_2H_5 + ROH \longrightarrow C_6H_5SO_3H + ROC_2H_5$$

Titrimetric method; first-order k for t in minutes; $k' = 0.4343k$; θ = 100°C (431)

ROH	$10^5k'$	ROH	$10^5k'$
Methyl alcohol	2311	Allyl alcohol	649
Ethyl alcohol	1130	Benzyl alcohol	346
Propyl alcohol	813	Isopropyl alcohol	373
Isobutyl alcohol	498	Capryl alcohol	105
act.-Isoamyl alcohol	546	Trimethyl carbinol	94 ↑
Octyl alcohol	420	Dimethylethyl carbinol	96 ↑

ETHER FORMATION FROM DIALKYL SULFATE IN ALCOHOLS (ROH) AS SOLVENT

$$R_2SO_4 + ROH \longrightarrow R'HSO_4 + ROR'$$

Titrimetric method; first-order k for t in minutes, $k' = 0.4343k$; θ = 55°C (314)

$R_2'SO_4$	ROH	$10^3k'$	Q_{10}
$(CH_3)_2SO_4$	CH_3OH	10.9	3.0
	C_2H_5OH	7.7	
	$CH_3(CH_2)_2OH$	6.0	
$(C_2H_5)_2SO_4$	CH_3OH	3.5	
	C_2H_5OH	2.15	2.1
	$CH_3(CH_2)_2OH$	1.9	

ESTER FORMATION FROM $(CH_3)_2SO_4$ IN CH_3OH AS SOLVENT

$$\underset{(a - x)}{(CH_3)_2SO_4} + \underset{(b - x)}{MX} \longrightarrow \underset{x}{CH_3X} + M(CH_3)SO_4$$

$$dx = k(a - x)(b - x)dt$$

Titrimetric method; second-order k for t in minutes and M/l (529)

MX	k, 0°	k, 12.6°	k, 25°	k, 40°
NaI	0.029	0.142	1.04	
NaCNS			0.196	0.804
KCNS			0.236	1.01

Reactivity of the Halogens in Organic Compounds

DOUBLE DECOMPOSITION OF ALCOHOLATES (RESP. PHENOLATES) WITH ALKYL HALIDES (RESP. CYANIDES) IN NON-AQUEOUS SOLUTIONS (WILLIAMSON ETHER SYNTHESIS)

$$\underset{a - x}{RONa} + \underset{b - x}{R'X} \longrightarrow ROR' + \underset{x}{NaX}$$

$$\frac{dx}{dt} = k(a - x)(b - x)$$

The bimolecular constant varies with the dilution, V, in l/M, from which it follows that phenolate and phenolate ion react with different velocities:

$$RO^- + R'X \xrightarrow{k_i} ROR' + X^-$$
$$RONa + R'X \xrightarrow{k_m} ROR' + NaX$$
$$-d[R'X] = (k_i[RO^-] + k_m[RONa])[R'X]dt$$

or, if k_v is the bimolecular constant and α the degree of dissociation at the dilution, V:

$$k = Vk_v = k_i\alpha + k_m(1 - \alpha)$$
$$\frac{k}{V} = k_v = \frac{a}{(b - a)t}\log_e\frac{a(b - x)}{b(a - x)}$$

Titrimetric method; units: minutes and M/l; solvent, C_2H_5OH (abs.) (0.01 – 0.03 % H_2O) (108); *cf.* (10, 11, 12, 14, 95, 354, 384, 426, 442, 493).

RONa	R'I	°C	k_i	k_m	$k_i:k_m$
C_6H_5ONa	CH_3I	25	0.0282	0.00474	5.95
		35	0.091	0.0131	6.74
C_2H_5ONa		25	0.127	0.0594	2.13
	C_2H_5I	25	0.0120	0.00472	2.81
	C_2H_5Br	25	0.00576	0.00233	2.41
	C_6H_5CN	25	0.1172	0.0976	1.14
	CH_3CN	25	0.344	0.228	1.51
$C_8H_6N_3OSNa$	C_2H_5CN	25	0.4625	0.1579	2.90

k_i and k_m can be computed from any pair of values of k and V. For example, the following reaction of sodium 1-phenyl-3-thiourazol with C_2H_5I at 25°C, yields:

$$k = 0.4625\alpha + 0.1579(1 - \alpha)$$

V	k, obs.	α	k, calc.
4	0.2265	0.248	0.2334
8	0.2575	0.334	0.2595
16	0.2895	0.421	0.2861
32	0.3120	0.514	0.3144
64	0.3350	0.607	0.3428

$$C_6H_5ONa + RI \longrightarrow C_6H_5OR + NaI$$

Titrimetric method; second-order k for t in minutes and M/l; $b = a = 0.2$; $\theta = 58.5$°C; solvent, various alcohols; D = dielectric constant of solvent at 20° (439).

Solvent	k		D
	C_2H_5I	$CH_3(CH_2)_2I$	
Methyl alcohol	0.0276	0.0115	31.2
Ethyl alcohol	0.0622	0.0249	25.8
Propyl alcohol	0.0381	0.0161	22.2
Isobutyl alcohol	0.0187	0.00798	20.0
Isoamyl alcohol	0.01245	0.00540	16.0

Effect of alkyl radical and temperature; solvent, C_2H_5OH(abs.); $b = a = 0.1$.

$$A' = \frac{T_1T_2(\log_{10} k_2 - \log_{10} k_1)}{T_2 - T_1}$$

calculated from the values of k at 31.0 and 58.5°C.

Effect of alkyl radical and temperature.—(*Continued*)

R of RI	k, 31.0°	k, 42.5°*	k, 58.5°	k, 80.1°	A'
Methyl	0.0155	0.0607	0.326		4850
Ethyl	0.00342	0.0135	0.0710	0.510	4825
n-Propyl	0.00128	0.00520	0.0288	0.209	4922
n-Butyl	0.00127	0.00485	0.0267	0.197	4845
n-Amyl	0.000545	0.00210	0.0117	0.085	4887
n-Hexyl	0.00121	0.00464	0.0255	0.192	4825
n-Heptyl	0.00116	0.00451	0.0248	0.190	4874
n-Octyl	0.00109	0.00434	0.0242	0.187	4933
n-Hexadecyl	0.00107	0.00429	0.0236	0.184	4918
Isobutyl	0.000512	0.00193	0.0103	0.0700	4778
Isoamyl	0.000727	0.00285	0.0156	0.0760	4880
Isopropyl	0.00123	0.00465	0.0259	0.193	4846
sec.-Butyl	0.00132	0.00513	0.0277	0.205	4844
sec.-Amyl	0.00120	0.00470	0.0260	0.197	4893
sec.-Hexyl	0.00113	0.00433	0.0240	0.178	4866
sec.-Heptyl	0.00110	0.00420	0.0230	0.170	4845
sec.-Octyl	0.00107	0.00411	0.0226	0.168	4848
tert.-Butyl†	0.0295	0.121			5100

* k for 42.5°C can be calculated from A' in good agreement with k, obs.
† k, 0° = 0.000 381 for $(CH_3)_3CI$.

$$C_6H_5CH_2ONa + RI \longrightarrow C_6H_5CH_2OR + NaI$$

Titrimetric method; units: minutes and M/l; solvent, C_2H_5OH (abs.); $b = a = 0.1$ (244.5).* The equilibrium:

$$C_6H_5CH_2ONa + C_2H_5OH \rightleftarrows C_2H_5ONa + C_6H_5CH_2OH$$

is reached very rapidly in this solvent with the result that the same k was found in both the following mixtures:

In C_2H_5OH solution	k, 40°
0.1N C_2H_5I + 0.1N $C_6H_5CH_2ONa$	0.04556
0.1N C_2H_5I + 0.1N C_2H_5ONa + 0.1N $C_6H_5CH_2OH$	0.04560

* Contains citations from earlier literature.

R of RI	10^5k				A'
	30°	40°	50°	60°	
Methyl	15 950				4 510
Ethyl	1 423	4 556	13 690		4 793
n-Propyl	554.4	1 772	5 119	14 350	4 765
Isopropyl	331.0	1 035	3 053	8 175	4 695
n-Butyl	401.1	1 297	3 768	10 310	4 737
Isobutyl	520.7	1 637	4 890	12 790	4 683
Isoamyl	203.4	726	2 089	5 133	4 695
sec.-Hexyl	576.8	1 830	5 407	14 595	4 731
n-Heptyl	400.7	1 297	3 776	10 160	4 716
n-Octyl	400.5	1 274	3 770	9 816	4 703
sec.-Octyl	435.2	1 395	4 129	11 300	4 750
Hexadecyl	414.2	1 276	3 640	9 826	4 624

CH_3I, 10^5k	383.6(0°)	5147 (20°)
C_2H_5I, 10^5k		414.2(20°)

The *relative constant*, k, referred to any RI as unit is dependent upon T, since in the equation:

$$k = e^{-\frac{A}{T} + I} = e^I e^{-\frac{A}{T}} = k_0 e^{-\frac{A}{T}}$$

the A's for various RI's are different. For $T = \infty$, $k = k_0$ is the *limiting velocity*. The *relative* limiting velocities are independent of T.

$$C_6H_4Br(NO_2) + C_2H_5ONa \longrightarrow C_6H_4(OC_2H_5)(NO_2) + NaBr$$

Titrimetric method; units: hours and M/l, $\theta = 50 \pm 0.1$°C; $a = b = 0.02 - 0.025$ (416)

Bromide	k in C_2H_5OH	
	99.16 Vol. %	90.7 Vol. %
$C_6H_4Br(1)NO_2(2)$	0.0000627	0.0000271
$C_6H_4Br(1)NO_2(4)$	0.000122	0.0000820
$C_6H_4Br(1)NO_2(3)$	Very small	Very small

$$RCl + KI \longrightarrow RI + KCl$$

Titrimetric method; second-order k for hours and M/l, $k' = 0.4343k$; solvent, absolute acetone (124)

RCl	k', 25°	k', 50°*	k, 60°	A'
$CH_3(CH_2)_3Cl$		0.0415	0.119	4 920
$CH_3(CH_2)_4Cl$			0.128	
$C_6H_5CH_2Cl$	0.774	(9.83)		3 920
$C_6H_5(CH_2)_2Cl$		0.0466	0.108	3 920
$C_6H_5(CH_2)_3Cl$		0.0713	0.160	3 770

$KCl + KI$.—(*Continued*)

RCl	k', 25°	k', 50°*	k', 60°	A′
$C_6H_5(CH_2)_4Cl$		0.0617	0.135	3 660
$C_6H_5(CH_2)_5Cl$		(0.0590)	0.129	3 660
$C_6H_5(CH_2)_6Cl$		(0.0607)	0.133	3 660
$C_6H_5(CH_2)_7Cl$		(0.0580)	0.127	3 660
$ClCO_2C_2H_5$	0.0954	(1.74)		4 850
$ClCH_2CO_2C_2H_5$	6.37	(116)		4 850
$Cl(CH_2)_2CO_2C_2H_5$		0.0667		
$Cl(CH_2)_3CO_2C_2H_5$		0.0686		
$Cl(CH_2)_4CO_2C_2H_5$		0.0562		
C_6H_5COCl		(90)		
$C_6H_5COCH_2Cl$		(12 600)		4 850
$C_6H_5CO(CH_2)_2Cl$		3.60		4 850
$C_6H_5CO(CH_2)_3Cl$		(15.4)		

* The values in parentheses are extrapolated.

Chloride	C_6H_5COCl	$C_6H_5COCH_2Cl$
k', 0°	0.16	22.4

In homologous series, "alternating polarity" or the so-called "saw-tooth" rule is noted.

$$\beta\text{-}C_{10}H_7ONa + C_2H_5I \longrightarrow \beta\text{-}C_{10}H_7OC_2H_5 + NaI$$

Titrimetric method; second-order k for t in minutes and M/l (127)

Solvent	k, 40.0°	k, 50.5°	k, 62.8°	Q_{10}	E
Ethyl alcohol	0.00790	0.0212	0.125	2.73	19 840
Isopropyl alcohol	0.00646	0.0177	0.101	2.75	19 990
Methyl alcohol	0.00460	0.0130	0.0875	2.89	21 010
n-Propyl alcohol	0.00442	0.0127	0.0868	2.93	21 300
n-Butyl alcohol	0.00404	0.0107	0.0631	2.70	19 650
Isobutyl alcohol	0.00399	0.0113	0.0525	2.70	19 650
Benzyl alcohol	0.00273	0.00781	0.0456	2.84	20 650
Isoamyl alcohol	0.00223	0.00649	0.0320	2.78	20 240
tert.-Amyl alcohol	0.000533	0.00155	0.00987	2.92	21 190

Q_{10} is calculated from E for range 37.8-47.8°.

E is calculated from:

$$\log_e \frac{k_1}{k_2} = \frac{E}{1.985}\left(\frac{1}{T_2} - \frac{1}{T_1}\right).$$

REARRANGEMENT IN AQUEOUS SOLUTION

$$C_6H_5NCl(COCH_3) \longrightarrow p\text{-}ClC_6H_4NH(COCH_3)$$

Acetochloroanilide *p*-Chloroacetanilide

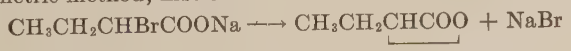
Titrimetric method; monomolecular k for t in minutes at 25°C is approximately proportional to $[H^+]^2$; effect of neutral salts (241)

Salt, N	0.5	0.6	0.8	1.0	1.2	1.5
KCl, 10^3k	6.83	7.65	9.30	11.10	12.8	15.3
NaCl, 10^3k	6.92	7.80	9.65	11.75	13.6	16.9

There is a simple relation between the activity of Cl^- and the acceleration caused by neutral salts if the concentration of H_2O, C_W, does not appear in the velocity equation (240). For the effect of degree of hydration of Cl^-, *see* (537, 538, 540). For kinetics of the reaction, *see also* (424).

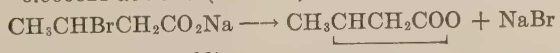
Formation of Lactone from the Salts of Organic Halogen Acids

Titrimetric method; first-order k for t in minutes.



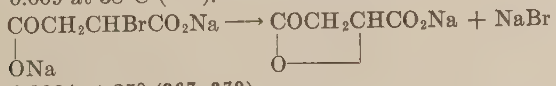
$$\mathrm{CH_3CH_2CHBrCOONa} \longrightarrow \mathrm{CH_3CH_2}\underbrace{\mathrm{CHCOO}} + \mathrm{NaBr}$$

k = 0.000021 at 25°C (265, 266).



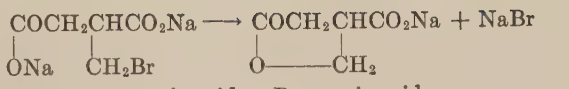
$$\mathrm{CH_3CHBrCH_2CO_2Na} \longrightarrow \mathrm{CH_3}\underbrace{\mathrm{CHCH_2COO}} + \mathrm{NaBr}$$

k = 0.009 at 38°C (280).



$$\underset{\mathrm{ONa}}{\mathrm{CO}}\mathrm{CH_2CHBrCO_2Na} \longrightarrow \underset{\mathrm{O}\text{———}}{\mathrm{COCH_2CH}}\mathrm{CO_2Na} + \mathrm{NaBr}$$

k = 0.0024 at 25° (267, 279).



$$\underset{\mathrm{ONa}}{\mathrm{CO}}\mathrm{CH_2}\underset{\mathrm{CH_2Br}}{\mathrm{CH}}\mathrm{CO_2Na} \longrightarrow \underset{\mathrm{O}\text{———}\mathrm{CH_2}}{\mathrm{COCH_2CH}}\mathrm{CO_2Na} + \mathrm{NaBr}$$

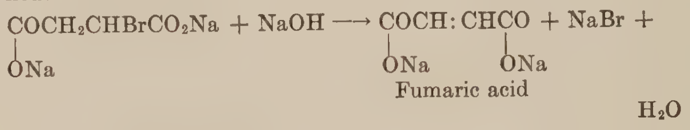
Itabromopyrotartaric acid Paraconic acid

k = 0.0072 at 0.05°C; = 0.30 at 25°C; Q_{10} = 4.46 (268).

Acids retard lactone formation. The latter is accompanied by saponification of the lactone as a follow-reaction and by the formation of unsaturated organic acids and their saponification to hydroxy acids as side-reactions. Alkalies promote both of these effects.

Formation of Unsaturated Organic Acids from Halogen Acids

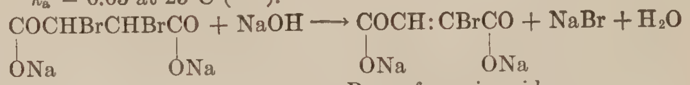
Titrimetric method; second-order k_a for alkaline saponification for t in minutes and M/l. The constant is greatly influenced by neutral salts.



$$\underset{\mathrm{ONa}}{\mathrm{CO}}\mathrm{CH_2CHBrCO_2Na} + \mathrm{NaOH} \longrightarrow \underset{\mathrm{ONa}}{\mathrm{CO}}\mathrm{CH{:}CH}\underset{\mathrm{ONa}}{\mathrm{CO}} + \mathrm{NaBr} + \mathrm{H_2O}$$

Fumaric acid

k_a = 0.05 at 25°C (279).



$$\underset{\mathrm{ONa}}{\mathrm{CO}}\mathrm{CHBrCHBr}\underset{\mathrm{ONa}}{\mathrm{CO}} + \mathrm{NaOH} \longrightarrow \underset{\mathrm{ONa}}{\mathrm{CO}}\mathrm{CH{:}CBr}\underset{\mathrm{ONa}}{\mathrm{CO}} + \mathrm{NaBr} + \mathrm{H_2O}$$

Bromofumaric acid

k_a = 1.13 at 19.4°C; = 2.00 at 25°C; = 2.87 at 30°C (264, 265, 266).

$$CH_2BrCHBrCO_2Na + NaOH \longrightarrow CH_2{:}CBrCO_2Na + NaBr + H_2O$$

k_a = 7.73 to 9.27 at 25°C (264, 265, 266).

$$CH_3CHBrCHBrCO_2Na + NaOH \longrightarrow CH_3CH{:}CBrCO_2Na + NaBr + H_2O$$

96.5% α-Bromocrotonic acid

3.5% α-Bromoallocrotonic acid

k_a = 0.134 to 0.160 at 25°C (264, 265, 266).

For the barium salts, k_a is larger.

Saponification of Organic Halogen Acids to Hydroxy Acids

Alkaline saponification of salts of halogen acetic acids.

$$CH_2XCO_2Na + NaOH \longrightarrow CH_2(OH)CO_2Na + NaX$$

Titrimetric method; bimolecular k_a of alkaline saponification for t in minutes and M/l at 25°C (269, 279)

X	k_a	Lit.
Cl	0.00005	(279)
Br	0.0026	
I	0.0013	(269)

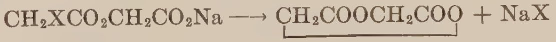
In neutral or acid solutions the saponification proceeds very slowly (167, 168, 440.5).

In concentrated solutions especially, it is accompanied by the following side- and follow-reactions (440.8):

$$2CH_2XCO_2Na \longrightarrow CH_2XCO_2CH_2CO_2Na + NaX$$

$$CH_2XCO_2CH_2CO_2Na + H_2O \longrightarrow CH_2XCO_2H + CH_2(OH)CO_2Na$$

$$CH_2XCO_2CH_2CO_2Na + H_2O \longrightarrow CH_2(OH)CO_2CH_2CO_2H + NaX$$



$$\mathrm{CH_2XCO_2CH_2CO_2Na} \longrightarrow \underbrace{\mathrm{CH_2COOCH_2COO}} + \mathrm{NaX}$$

Reaction of Free Halogen Acetic Acid

$$CH_2XCO_2H + H_2O \longrightarrow CH_2(OH)CO_2H + HX$$

Titrimetric method; first-order k for t in minutes (168)

Acid	10^6k								
	40°	50°	60°	65°	70°	75°	80°	85°	90°
CH_2ClCO_2H				8.2	16	25	34	55	80
CH_2BrCO_2H	17	41	99						

For reaction of halogen acetic acids with KCNS and $Na_2S_2O_3$, *see* (147, 270, 310, 311).

The Action of Halogens on Organic Substances Containing Oxygen

Action of Iodine on Acetone in Aqueous Solution

$$CH_3COCH_3 + I_2 \longrightarrow CH_3COCH_2I + H^+ + I^-$$
$$-d[CH_3COCH_3] = k[CH_3COCH_3][H^+]dt$$

According to (138, 142, 331) the mechanism of the reaction is:

$$CH_3COCH_3 \leftrightarrows CH_3C(OH){:}CH_2 \text{ (slow)}$$
$$CH_3C(OH){:}CH_2 + I_2 \longrightarrow CH_3COCH_2I + H^+ + I^- \text{ (rapid)}$$
$$CH_3COCH_3 + I_2 \longrightarrow CH_3COCH_2I + H^+ + I^- \text{ (net reaction)}$$

The enolization of acetone catalyzed by H^+ is the rate-determining reaction.

Weight-titrimetric method; units: minutes and M/l; catalyst, HCl; M = accuracy of measurement in % (418)

°C	0	24	25	27	35
10^4k	0.6994	15.187	17.148	21.609	52.840
M	0.10	0.20	0.070	0.14	0.10

Temp. interval, °C	0–24	25–27	27–35
Q_{10}	3.605	3.181	3.057
A	20 669	20 540	20 528

The Arrhenius constant, A, shows a tendency to fall with rise of temperature.

Non-electrolytes change the value of k but not that of A; for the effect of electrolytes on these constants, *see* (419). For acceleration of the reaction by various acids and its autocatalysis, *see* (138, 141).

Same Reaction with Different Ketones in 40% C_2H_5OH

Titrimetric method; first-order k for t in minutes; θ = 25°C; catalyst 0.2N H_2SO_4 (139, 142)

Ketone	10^6k	Ketone	10^6k
CH_3COCH_3	288	$CH_3COC_6H_5$	108
$C_2H_5COC_2H_5$	236	$CH_3COCH_2C_6H_5$	395
$C_3H_7COC_3H_7$	202	$C_2H_5COC_6H_5$	24
$CH_3COC_2H_5$	300	p-$CH_3COC_6H_4Br$	90
$CH_3COC_3H_7$	270	p-$CH_3COC_6H_4I$	90*
$CH_3COCH(CH_3)_2$	200	p-$CH_3COC_6H_4NH_2$	80
$CH_3CO(CH_2)_3CH_3$	318	m-$CH_3COC_6H_4NO_2$	45
$CH_3COCH_2CH(CH_3)_2$	247	$CH_2BrCOC_6H_5$	0
$CH_3COC(CH_3)_3$	132		
$CH_3COC_6H_{13}$	306		

* Solvent = 60 % C_2H_5OH.

Oxidation of Acetaldehyde by Bromine in Aqueous Solution

$$CH_3CHO + Br_2 + H_2O \longrightarrow CH_3CO_2H + 2H^+ + 2Br^-$$
$$-d[CH_3CHO] = k[CH_3CHO][Br_2]dt$$

Titrimetric method; units: minutes and M/l (97, 140)

°C*	0	10	20	25	18
k	0.117	0.308	0.790	1.205	0.654
Q_{10}		2.64	2.55	2.33	

* The values at 18°C are from (140); all others from (97). For the side-reaction, *see* (140).

Action of Bromine on Acetic Anhydride Used as Its Solvent

$$(CH_3CO)_2O + Br_2 \xrightarrow{k} CH_2BrCO_2H + CH_3COBr$$

Titrimetric method: $-dx = kdt$, where x = concn. of Br_2;

$$(CH_3CO)_2O \leftrightarrows CH_2{:}C(OH)OCOCH_3 \text{ (rate-determining, catalyzed)}$$
$$CH_2{:}C(OH)OCOCH_3 + Br_2 \longrightarrow CH_2BrCO_2H + CH_3COBr \text{ (rapid)}$$

Units: minutes and g-atom Br/l; C = concn. of catalyst in M/l; θ = 25°C (393).

Catalyst	$100C$	$100k$	Catalyst	$100C$	$100k$
H_2SO_4	0.2	1.11	$SnCl_4$	0.097	0.77
	0.4	1.33		0.19	0.78
	0.8	2.23	$SnBr_4$	0.06	0.81
$FeCl_3$	0.06	1.39		0.12	0.96
	0.12	2.26		0.31	1.30
	0.24	4.20		0.50	1.60
	0.48	3.98	CH_3COCl	27	0.82
$FeBr_3$	0.065	3.38		54	0.50
HCl	2.72	0.96		81	0.62

Miscellaneous Organic Reactions

Cannizzaro Reaction of Aldehydes in Aqueous Solution

$$2CH_2O + NaOH \longrightarrow HCO_2Na + CH_3OH$$
$$-d[OH^-] = k[CH_2O][OH^-]dt$$

Titrimetric method; units: minutes and M/l (169); *cf.* (171, 407)

°C	50	65	75	85
10^3k	5.5	30.2	93	294
Q_{10}		3.1	3.1	3.1

For reaction of C_6H_5CHO, *see* (407).

Phenylhydrazone Formation in 95% Alcohol

$$\underset{a - x}{C_6H_5NHNH_2} + \underset{b - x}{CH_3COC_6H_5} \xrightarrow{k} C_6H_5NHN{:}C(C_6H_5)(CH_3) + H_2O$$

Titrimetric method; second-order k for t in minutes and M/l; θ = 18°C (53)

a	b	$[HC_2H_3O_2]$	$[KC_2H_3O_2]$	k
0.1	0.1	0.01	0.1	0.26
0.06	0.06	0.01	0.1	0.23
0.075	0.075	0.01	0.1	0.25
0.05	0.1	0.01	0.1	0.24
0.05	0.05	0.01	0.25	0.15

CN^- Catalysis of the Benzoin Synthesis

$$\underset{a - x}{2C_6H_5CHO} \xrightarrow{k} C_6H_5CH(OH)COC_6H_5$$
$$dx = k(a - x)^2dt;\ k = k_1[CN^-]$$

Gravimetric method; units: minutes and M/l (82, 500); solvent: 10 cm³ H_2O + 20 cm³ C_2H_5OH; k_1 = 0.089(0.085 to 0.092) at 60°C; A = 6572.

Effect of solvent at 60°C and $[CN^-]$ = 0.1

cm³ H_2O	cm³ C_2H_5OH	$100k$	cm³ H_2O	cm³ CH_3OH	$100k$
5	25	0.87	5	25	0.45
15	15	1.16	10	20	0.65
20	10	1.24	15	15	0.91

Nitrile Formation in the Melt

$$\underset{(1 - x)}{(C_6H_5CO)_2O} + \underset{(1 - x)}{C_6H_5CONH_2} \xrightarrow{k} 2C_6H_5CO_2H + C_6H_5CN$$
$$dx = k(1 - x)^2dt$$

Method: temperature of primary crystalization of system.

$$(1 - x)[(C_6H_5CO)_2O + C_6H_5CONH_2] + x[2C_6H_5CO_2H + C_6H_5CN]$$

k = 0.053(0.050 to 0.055) at 98°C; t in hours (318). For methods, *see further* (316, 317, 317.5, 318.5).

Chlorination of Nitrobenzene (as Solvent)

$$C_6H_5NO_2 + Cl_2 \longrightarrow C_6H_4Cl(3)(NO_2)(1) + HCl$$
$$-d[Cl_2] = kC[Cl_2]dt$$

Titrimetric method; t in minutes; C = concn. of catalyst in M/l (213)

Catalyst	k, 50°	k, 100°	Q_{10}
$SnCl_4$	0.000778		
$AlCl_3$	0.0239	0.131	1.35

The Friedel-Crafts Reaction

$$CH_3OC_6H_5 + C_6H_5CH_2Cl \longrightarrow CH_3O(1)C_6H_4(4)CH_2C_6H_5 + HCl$$

$$-d[C_6H_5CH_2Cl] = k[AlCl_3][C_6H_5CH_2Cl]dt$$

Solvent, $CH_3OC_6H_5$; catalyst, $AlCl_3$; units: minutes and M/l; $k = 0.46$ at 0°C; $= 2.0$ at 20°C (213); *cf.* (95.5, 488).

Relative Velocity of Sulfonation of Phenols

$$C_6H_5OH + H_2SO_4 \longrightarrow C_6H_4(OH)(SO_3H) + H_2O$$

If the velocity of sulfonation of phenol is taken as 1, then that for each of the three cresols is as follows (105):

°C	20	40	60	80
o-Cresol	0.773	0.859	0.894	0.905
m-Cresol	1.395	1.362	1.118	0.399
p-Cresol	0.300	0.474	0.573	0.287

m-Cresol: *p*-Cresol = 1.059(100°).

m-Cresol: *m*-4-Xylenol = 3.020(40°); = 1.284(80°).

m-Cresol: *p*-Xylenol = 1.260(40°); = 1.297(80°).

These relationships are important in the separation of phenols in crude carbolic acid (355).

Nitration of Aromatic Substances (20); *cf.* (261, 301, 550)

$$C_6H_5OH + HNO_3 \longrightarrow C_6H_4(OH)(NO_2) + H_2O$$

The reaction is autocatalytic, thus:

$$HNO_3 + HNO_2 \rightleftarrows N_2O_4 + H_2O$$

$$C_6H_5OH + N_2O_4 \longrightarrow C_6H_4(OH)(NO_2) + HNO_2$$

Oxidation of Naphthalene to Phthalic Acid by Means of H_2SO_4

$$C_{10}H_8 + 9H_2SO_4 \longrightarrow C_6H_4(CO_2H)_2 + 9SO_2 + 2CO_2 + 10H_2O$$

Gas-volumetric method; solvent, H_2SO_4; monomolecular k for t in minutes, $k' = 0.4343k$; mixture: 40 cm³ H_2SO_4; 0.0480 g $C_{10}H_8$; 0.28 g Hg_2SO_4 as catalyst (70, 94).

°C	300	275	250	225
$10^5k'$, without catalyst	*ca.* 178	21	2.2	
$10^5k'$, with catalyst	*ca.* 800	165	26	2.8

Slight amounts of water are without appreciable influence. $CuSO_4$ is a less satisfactory catalyst than Hg_2SO_4; the simultaneous action of both catalysts is more than additive. With increase of temperature, the uncatalyzed reaction gains the upper hand.

Reduction of Azo Compounds by $SnCl_2$ in Aqueous HCl (Resp. by $SnBr_2$ in Aqueous HBr)

$$XN{:}NY \longrightarrow XNH_2 + YNH_2$$

Colorimetric method; units: minutes and M/l; $\theta = 25$°C (205)

Reduction with $SnCl_2$ and HCl:

$$-d[XN_2Y] = k_0[XN_2Y][SnCl_2]dt$$
$$k_0 = k[H^+][Cl^-]^2$$
$$k_0 = k_1[Cl^-] + k_2[H^+][Cl^-]^2$$
$$k_0 = k_3[Cl^-]$$
$$k_0 = k_4 + k_5[Cl^-]$$

XN_2Y	k	k_1	$10^{-2}k_2$	k_3	k_4	k_5
Azobenzenetrimethylammonium chloride	991					
Azobenzene-*m*,*m*′-disulfonic acid	175					
p-Dimethylaminoazobenzene	368					
p-Diethylaminoazobenzene	955					
p-Aminoazobenzene	726					
Methyl orange	69.5					
β-Naphthylaminoazobenzenesulfonic acid		260	66.2			
Benzeneazo-α-naphthylamine-4, 7-disulfonic acid		596	134.7			
Naphthionic acid-azobenzenesulfonic acid		506	329.3			
Chrysoidin T		7.5	5.2			
p-Hydroxyazobenzene		4.4	1.4			
Tropäolin Y	521					
α-Naphthol orange		99.6	0.9			
β-Naphthol orange				25.8		
Ponceau 4GB					1.8	23.9
Ponceau G					6.7	10.7
Ponceau 2R					1.15	1.45

Reduction with $SnBr_2$ and HBr:

$$-d[XN_2Y] = k_0[XN_2Y][SnBr_2]dt$$
$$k_0 = k[Br^-]^3$$
$$k_0 = k_1[H^+][Br^-]^2$$
$$k_0 = k_2 + k_3[Br^-]$$

XN_2Y	$10^{-2}k$	$10^{-2}k_1$	k_2	k_3
m,*m*′-Azobenzenedisulfonic acid	12.1			
Dimethylaminoazobenzene		9.48		
Diethylaminoazobenzene		23.9		
Benzeneazo-β-naphthol-3, 6-disulfonic acid			30	157

For the reduction of nitro compounds by $SnCl_2$, *see* (202, 210, 219, 302).

Hydrolysis of Amino Acids in Aqueous Solution at 100°C (561)

$$CH_3CH(NH_2)CO_2H + H_2O \longrightarrow CH_3CH(OH)CO_2^- + NH_4^+$$

The reaction takes place only with animal charcoal as catalyst. No hydrolysis is observed in the absence of catalyst.

The reaction proceeds to the equilibrium:

$$[CH_3CH(OH)CO_2^-][NH_4^+] = K_E[CH_3CH(NH_2)CO_2H]$$

But the kinetics of the process corresponds to a reaction without reversal:

$$dx = k(a - \xi - x)dt.$$

$$k = \frac{1}{t}\log_e \frac{a - \xi}{a - \xi - x} \text{ for } t \text{ in minutes.}$$

$k' = 0.4343k.$

a = initial concentration of amino acid in M/l.

ξ = equilibrium concentration, or, more exactly, concentration of amino acid at the end of the reaction.

Alanine			Aspartic acid		
a	$1{:}K_E$	$100k'$	a	$1{:}K_E$	$100k'$
0.0422	56.8	6.4 − 5.3	0.0315	18.5	3.9 − 5.4
0.080	73.5	7.1 − 5.8	0.0593	15.4	6.7 − 6.5
0.116	77.0	7.6 − 6.1	0.0795	17.9	7.3 − 6.9

For further examples of one-sided equilibria and for the theory, *see* (32, 565).

Inorganic Oxidation-Reduction Reactions

The symbols in square brackets denote concentration in M/l, in parentheses, the analytic or total concentration in M/l.

Examples:

$$(AsO_2^-) = [HAsO_2] + [AsO_2^-] + [H_3AsO_3] + [H_2AsO_3^-] + [HAsO_3^{--}] + \cdots$$

$$(SO_2) = [SO_2] + [H_2SO_3] + [HSO_3^-] + [SO_3^{--}]$$

Decomposition of $Na_2S_2O_4$ in Aqueous Solution

$$\underset{a\,-\,x}{2Na_2S_2O_4} + H_2O \xrightarrow{k} 2NaHSO_3 + \underset{c\,=\,\text{constant}}{Na_2S_2O_3}$$

$$dx/dt = kc^2(a - x)^2$$

Titrimetric method; t in minutes; c and a in g/100 g soln.; values of kc^2 for c = 15 (278.5).

°C	0	10	20	30
10^4kc^2	1.4	2.3	3.7	6.3

$Q_{10}(0 - 30°) = 1.65.$

Recalculated to M/l: $-d(Na_2S_2O_4) = 0.003(NaHSO_3)^2 \times (Na_2S_2O_4)^2dt(20°)$.

Decomposition of Nitrous Acid in Aqueous Solution

$$3HNO_2 \underset{\longrightarrow}{\overset{k}{\longleftarrow}} 2NO + HNO_3 + H_2O$$

Titrimetric method; first-order k for t in minutes; R = velocity in liters per minute of the inert gases (N_2, H_2) which are bubbled through the solution (302.5). The process defining the velocity is the escape of NO from the system. For more recent data, *v.* (8.5, 564).

°C	15	15	15	15	30	30
R	0.56	0.93	0.56	0.77	0.03	0.77
$[HNO_3]$	1.185	1.185	3.626	3.626	3.626	3.626
$100k$	3 7	4 5	5.0	8.0	1.2	1.0

Catalytic Decomposition of $K_2S_2O_8$ at 18°C in Aqueous Solution Catalyzed by $AgNO_3$

$$K_2S_2O_8 + H_2O \longrightarrow 2KHSO_4 + \tfrac{1}{2}O_2$$

$$-d[S_2O_8{}^{--}] = k[Ag^+][S_2O_8{}^{--}]dt$$

Titrimetric method; t in minutes (253).

$[Ag^+]$	$k[Ag^+]$	k
0.004	0.00079	0.20
0.01	0.00210	0.21
0.02	0.00375	0.19

Mean k = 0.20.

Decomposition of $H_2S_2O_8$ in Aqueous Solution of H_2SO_4 at 50°C

A first-order reaction in two stages with reversal:

$$H_2S_2O_8 + H_2O \underset{k_2}{\overset{k_1}{\rightleftarrows}} H_2SO_5 + H_2SO_4$$

$$H_2SO_5 + H_2O \underset{k_4}{\overset{k_3}{\rightleftarrows}} H_2SO_4 + H_2O_2$$

$$(H_2SO_4) = \text{constant}$$

Titrimetric method; t in seconds (397).

(H_2SO_4)	$100k_1$	$1000k_3$	10^5k_4	$k_1:k_3$	$k_1:(H_2SO_4)$
5.00	8.758	2.244	4.5	39.0	0.01752
3.76	3.026	0.760		39.8	0.00804
2.50	1.043	0.262		39.8	0.00418

k_2 is measurable only at very high (H_2SO_4). For the above computations of k_1 and k_3, k_2 and k_4 were taken as zero.

To a slight extent the following simultaneous reactions take place:

$$H_2SO_5 + H_2O_2 \xrightarrow{k_5} H_2SO_4 + H_2O + O_2$$

$$2H_2SO_5 \xrightarrow{k_6} 2H_2SO_4 + O_2$$

$$\frac{d[O_2]}{dt} = k_5\,[H_2SO_5]\,[H_2O_2] + k_6\,[H_2SO_5]^2$$

(H_2SO_4)	10^6k_5	10^7k_6
5.00	4.3	9
3.76	8.9	9
2.50	53.0	112

The loss of active oxygen through evolution of O_2 increases greatly with decreasing (H_2SO_4). For strongly acid solution it is negligible.

Action of Persulfate on Iodine in Aqueous Solution

$$S_2O_8{}^{--} + 2I^- \longrightarrow 2SO_4{}^{--} + I_2$$

Titrimetric method; t in minutes (409).

$$-d[S_2O_8{}^{--}] = 0.16[S_2O_8{}^{--}][I^-]dt \text{ at } 25°C$$

Oxidation of Thiosulfate by H_2O_2 in Aqueous Solution with and without Catalyst

Titrimetric method; solvent, acetic acid; t in minutes (2, 2.5).

Catalyst, I^-

$$\frac{-d[H_2O_2]}{dt} = 1.53[H_2O_2][S_2O_3{}^{--}] + 0.7[I^-][H_2O_2] \text{ at } 25°C$$

Catalyst, Cu^{++}

$$\frac{-d[H_2O_2]}{dt} = 1.53[H_2O_2][S_2O_3{}^{--}] + 1.0 \times 10^3[Cu^{++}][H_2O_2] \text{ at } 25°C$$

$$4H_2O_2 + S_2O_3{}^{--} \longrightarrow 2SO_4{}^{--} + 2H^+ + 3H_2O \text{ (6)}$$

Catalyst, molybdic acid

$$\frac{-d[H_2O_2]}{dt} = \left\{0.75 \times 10^3 + 1.75 \times 10^7[H^+]\right\}[S_2O_3{}^{--}](MoO_3) \text{ at } 25°C$$

Formation of Iodate from Iodine in Aqueous Alkaline Solution

$$3I_3{}^- + 6OH^- \longrightarrow 8I^- + IO_3{}^- + 3H_2O$$

$$3I_2 + 6OH^- \longrightarrow 5I^- + IO_3{}^- + 3H_2O$$

Titrimetric method; t in minutes; θ = 25°C (445, 446, 447, 464).

For the *rapid* reaction:

$$\frac{-d[I_3{}^-]}{dt} = 2.0\,\frac{[OH^-][I_3{}^-]^2}{[I^-]^3} \qquad \text{(I)}$$

For the *slow* iodate formation:

$$\frac{-d[I_3{}^-]}{dt} = 2.3 \times 10^{11}\frac{[OH^-]^4[I_3{}^-]^3}{[I^-]^6} \qquad \text{(II)}$$

$$\frac{-d[I_2]}{dt} = 4.1 \times 10^{19}\,\frac{[OH^-]^4[I_2]^3}{[I^-]^3} \qquad \text{(III)}$$

Values of Q_{10} for I, II, III in various buffer solutions

	Q_{10}			
	NaOH	$Na_2CO_3/NaHCO_3$	Na_2HPO_4/NaH_2PO_4	NaAc/HAc*
I	3	6		
II	3.6	45		*ca.* 100
III			50	

* Ac = Acetate radical.

Formation of Bromate from Bromine in Aqueous Alkaline Solution

$$3Br_3{}^- + 6OH^- \longrightarrow 8Br^- + BrO_3^- + 3H_2O$$

Titrimetric method; t in minutes; θ = 25°C (483).

For the *rapid* bromate formation:

$$\frac{-d[Br_3^-]}{dt} = 6.5\ \times 10^4\ \frac{[OH^-][Br^-]^2}{[Br^-]^3}$$

For the *slow* reaction:

$$\frac{-d[Br_3^-]}{dt} = 3.8 \times 10^{22}\ \frac{[OH^-]^4[Br^-]^3}{[Br^-]^7}$$

Formation of Halogenate in Aqueous Solution of Hypohalogenite and Hypohalogenous Acids

$$3XO^- \longrightarrow 2X^- + XO_3{}^- \qquad \text{(net reaction)}$$

Titrimetric method (179, 181, 319); steady state in electrolysis of NaCl (374.5); *cf.* (180, 303, 486).

$$-d[XO^-] = k[XO^-][HXO]^2dt;\ t \text{ in minutes}$$

XO^-	k, 15°	k, 25°
ClO^-	1.12 (374.5)	1.6 (179)
BrO^-		170 (319)

Decomposition of Hypochlorite in Strongly Alkaline Solution

$$3ClO^- \xrightarrow{k} 2Cl^- + ClO_3{}^-$$

Titrimetric method; bimolecular k; t in days (149.5, 180).

$$\frac{-d[ClO^-]}{dt} = k[ClO^-]^2$$

(NaOH)	0.1	0.5	2.0
k, 25°	0.0022	0.0023	0.0028*
k, 50°	0.0455	0.0512	0.08 ↑ *
k, 90°	4.9*		

* The reaction proceeds with O_2-evolution as a simultaneous reaction.

Mechanism of the reaction:

$$\begin{array}{ll} 2ClO^- \xrightarrow{k_1} Cl^- + ClO_2^- & \text{(slow)} \\ ClO^- + ClO_2^- \xrightarrow{k_2} Cl^- + ClO_3^- & \text{(rapid)} \\ \hline 3ClO^- \xrightarrow{k} 2Cl^- + ClO_3^- & \text{(net reaction)} \end{array}$$

Values of bimolecular k_1 and k_2 for $0.1N$ NaOH; t in hours

°C	25	50	Q_{10}
k_1	0.00010	0.0019	3.16
k_2	0.0035	0.050	2.88

For this reaction and the analogous hypobromite reaction, *see* (112, 198).

DECOMPOSITION OF HYPOBROMITE IN NA_2CO_3 AND $NAHCO_3$ SOLUTION (445)

$$3NaBrO \longrightarrow 2NaBr + NaBrO_3$$

Titrimetric method; t in minutes; $\theta = 25°$

$$\frac{-d(NaBrO)}{dt} = 2 \times 10^{-4} \frac{[Br^-](NaBrO)^2}{[OH^-]}$$

DECOMPOSITION OF HYPOIODITE IN STRONGLY ALKALINE SOLUTION

$$3NaIO \longrightarrow 2NaI + NaIO_3$$

Titrimetric method; t in minutes; $\theta = 25°C$ (444, 445, 446, 466); *cf.* (96, 118, 182, 339, 404, 438).

For solution rich in I^-:

$$\frac{-d(NaIO)}{dt} = 87\,\frac{[I^-](NaIO)^2}{[OH^-]}; \qquad Q_{10} = 2.1$$

For solution poor in I^-:

$$\frac{-d(NaIO)}{dt} = 2\,\frac{(NaIO)^2}{[OH^-]}; \qquad Q_{10} = 2.5$$

HYDROLYSIS OF FREE THIOCYANATE (48)

$$3(CNS)_2 + 4H_2O \longrightarrow 5H^+ + 5CNS^- + HCN + H_2SO_4$$

Titrimetric method; t in minutes; $\theta = 18°C$.

$$\frac{-d[(CNS)_2]}{dt} = 5\frac{[(CNS)_2]^2}{[H^+]^2[CNS^-]^2}; Q_{10} = 2.84$$

$$3(H_2O + (CNS)_2 \rightleftarrows H^+ + CNS^- + CNSOH)$$

(preliminary equilibrium)

$$2CNSOH \longrightarrow CNS^- + H^+ + HCNSO_2$$

(rate-determining velocity)

$$HCNSO + HCNSO_2 \longrightarrow H^+ + CNS^- + HCNSO_3 \text{ (rapid)}$$

$$HCNSO_3 + H_2O \longrightarrow HCN + H_2SO_4 \text{ (rapid)}$$

$$\overline{3(CNS)_2 + 4H_2O \longrightarrow 5H^+ + 5CNS^- + HCN + H_2SO_4}$$

(net reaction)

The hydrolysis of free thiocyanate determines also the velocity of auto-reduction of $Au(CNS)_4^-$:

$$3Au(CNS)_4^- + 4H_2O \longrightarrow 3Au(CNS)_2^- + 5H^+ + 5CNS^- + HCN + H_2SO_4$$

HYDROLYSIS OF CHLORINE DIOXIDE, CLO_2

$$6ClO_2 + 3H_2O \longrightarrow 5ClO_3^- + Cl^- + 6H^+$$

Titrimetric method; t in minutes (63, 64).

$$\frac{-d[ClO_2]}{dt} = k[ClO_2]^2[Cl^-] + k_1[ClO_2]^2[Cl^-][H^+]$$

$$k = 0.056 \text{ at } 60°C; Q_{10} = 2.25$$

$$2ClO_2 + 2NaOH \longrightarrow NaClO_2 + NaClO_3 + H_2O$$

$$\frac{-d[ClO_2]}{dt} = k[ClO_2]^2[OH^-]$$

$$k = 300 \text{ at } 0°C; = 950 \text{ at } 19°C; Q_{10} = 1.8$$

DECOMPOSITION OF CHLORIC ACID BY HCL

$$2ClO_3^- + 2Cl^- + 4H^+ \longrightarrow 2ClO_2 + Cl_2 + 2H_2O$$

Method: Removal of reaction products by a stream of inert gas; t in minutes; $\theta = 50°C$ (348).

$$-d[ClO_3^-] = 0.001[ClO_3^-]^2[Cl^-]^2[H^+]^4dt$$

REDUCTION OF IODIC ACID BY HYDROIODIC ACID

$$IO_3^- + 8I^- + 6H^+ \longrightarrow 3I_3^- + 3H_2O$$

Titrimetric method; t in minutes (159).

$$\frac{-d[IO_3^-]}{dt} = k_1[IO_3^-][H^+]^2[I^-]^{1.9} + k_2[IO_3^-][H^+]^2[I^-][I_3^-]$$

H^+ buffer: acetic acid + acetate

°C	0	14	37	0*
$10^{-10}k_1$	2.54	3.90	5.90	0.84
$10^{-10}k_2$	1.70			0.32

* These values at 0°C were obtained in mineral acid solution.

At $\theta = 25°$, $k_1 = 5.33 \times 10^{10}$ (432); $= 5.29 \times 10^{10}$ (447).

$$\frac{-d[IO_3^-]}{dt} = [IO_3^-][I^-][H^+]^2\{7.6[I^-] + 5.5[I_3^-]\} \times 10^{10}F \text{ at } 25°C$$

$F = 10^{-2.20\sqrt{I}}$ for H_2SO_4 solution.

$F = 10^{-0.20\sqrt{I+0.50I}}$ for CH_3CO_2H solution.

Where $I = \Sigma_i C_i Z_i^2$ = ion concentration according to the theory of (9).

REDUCTION OF HALOGENATE BY HALIDE IN ACID SOLUTION, WITH OR WITHOUT REMOVAL OF THE REACTION PRODUCTS BY MEANS OF H_3ASO_3 OR H_2SO_3

Titrimetric method or simultaneous kinetics of the Landolt reaction; t in minutes; $\theta = 25°C$.

$$\frac{-d[XO_3^-]}{dt} = Kf(c); X = Cl, Br, I$$

No.	f(c)	K	Q_{10}	Lit.
1	$[IO_3^-][H^+]^2[I^-]^2$	5300×10^7	1.25	(159, 447, 448)
2	$[IO_3^-][H^+]^2[I^-][Br^-]$	600×10^7*		(475)
3	$[IO_3^-][H^+]^2[I^-][Cl^-]$	6×10^7*		
4	$[IO_3^-][H^+]^2[Br^-]^2$	6600*		
5	$[IO_3^-][H^+]^2[Br^-][Cl^-]$	6000*		
6	$[IO_3^-][H^+]^2[Cl^-]^2$	600*		
7	$[BrO_3^-][H^+]^2[I^-]$	4900	1.9	(113, 385)
8	$[BrO_3^-][H^+]^2[Br^-]$	200	2.0	(34, 286, 482)
9	$[BrO_3^-][H^+]^2[Cl^-]$	30		(482)
10	$[ClO_3^-][H^+]^2[I^-]$	0.0008	2.6	(61, 64)
11	$[ClO_3^-][H^+]^2[Br^-]$	0.0005†		
12	$[ClO_3^-][H^+]^2[Cl^-]$	0.0001‡	2.7	(61, 64)

* At room temperature.

† Interpolated.

‡ Products removed by I^-.

REDUCTION OF IODIC ACID BY SULFUROUS ACID

$$IO_3^- + 3SO_3^{--} \longrightarrow I^- + 3SO_4^{--}$$

The reaction is the initial step of the Landolt reaction; *cf.* (162, 163, 330.5, 486, 510, 511).

For the region of $[H^+] = 10^{-3}$ with t in seconds and $\theta = 16°C$ (455):

$$\frac{-d[IO_3^-]}{dt} = 0.34 \times 10^3(SO_3^{--})[IO_3^-][H^+]; Q_{10} = 1.3$$

Simultaneous reactions:

$$IO_3^- + 3HSO_3^- \longrightarrow I^- + 3SO_4^{--} + 3H^+$$

$$IO_3^- + 3SO_3^{--} \longrightarrow I^- + 3SO_4^{--}$$

In the range $[H^+] = 10^{-4}$ to 10^{-13}, for t in minutes at 25°C (486) the rate law is:

$$\frac{-d[IO_3^-]}{dt} = 0.53 \times 10^6[H^+][HSO_3^-][IO_3^-] + 0.67 \times 10^{17}[H^+]^2[SO_3^{--}]^2[IO_3^-]$$

REDUCTION OF PERIODATE IN ACETIC ACID SOLUTION

$$[IO_4^-] + AsO_2^- \longrightarrow IO_3^- + AsO_3^-$$

Titrimetric method; t in minutes; $\theta = 25°C$ (7).

$$-d[IO_4^-] = 5.5[IO_4^-](AsO_2^-)dt$$

$$IO_4^- + 2I^- + 2H^+ \longrightarrow IO_3^- + I_2 + H_2O$$

Acetic acid-acetate buffer; measured quantities of $HAsO_2$ present; method depended upon determination of time of first appearance of iodine color; for t in minutes at 25°C (8).

$$-d[IO_4^-] = k[IO_4^-][I^-]dt$$

$k = 380$ to 545 according to the salt content.

REDUCTION OF POTASSIUM DICHROMATE BY HYDROIODIC ACID

$$Cr_2O_7^{--} + 9I^- + 14H^+ \longrightarrow 3I_3^- + 2Cr^{+++} + 7H_2O$$

Titrimetric method; t in minutes; $\theta = 0°C$ (146, 199, 252).

$$\frac{-d[I_3^-]}{dt} = 10^3(Cr_2O_7^{--})[H^+]^2[I^-] + 0.25 \times 10^3(Cr_2O_7^{--})[H^+][I^-]^2;$$

$Q_{10} = 1.4$.

REDUCTION OF ARSENIC ACID BY HYDROIODIC ACID AND THE REVERSE REACTION

$$H_3AsO_4 + 2H^+ + 3I^- \overset{k_1}{\underset{k_2}{\leftrightarrows}} H_3AsO_3 + I_3^- + H_2O$$

Titrimetric method; t in minutes; $\theta = 0°C$ (427.5); *cf.* (58, 62); for the determination of the equilibrium constant at 25°C, *v.* (539).

$$\frac{d[I_3^-]}{dt} = k_1(H_3AsO_4)[I^-][H^+] - k_2\frac{(H_3AsO_3)[I_3^-]}{[I^-]^2[H^+]}$$

$k_1 = 3 \times 10^{-3}$; $Q_{10} = 2.2$.

$k_2 = 4.7 \times 10^{-4}$; $Q_{10} = 3.5$.

The equilibrium constant, K, for 0°C then becomes:

$$\frac{(H_3AsO_4)[I^-]^3[H^+]^2}{(H_3AsO_3)[I_3^-]} = \frac{k_2}{k_1} = K = 0.16$$

A PERIODIC REACTION IN HOMOGENEOUS SOLUTION (65); *cf.* (315, 342)

The periodicity refers to the iodine determined by colorimetric method in the following reaction mixture (M/l) at 25°C:

$$0.0327H_2O_2 + 0.0090HIO_3$$

After 29 days the concentration of H_2O_2 had decreased to about 93%; *see* figure below.

The following reactions also take place in the mixture:

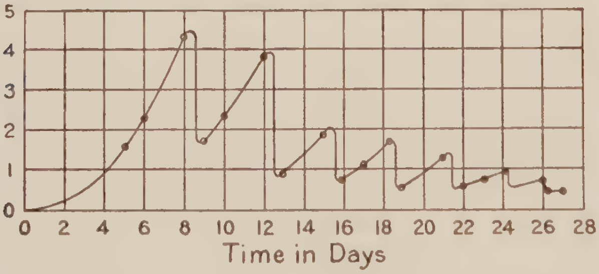
$$5H_2O_2 + I_2 \longrightarrow 2HIO_3 + 4H_2O \qquad (1)$$

$$5H_2O_2 + 2HIO_3 \longrightarrow 5O_2 + I_2 + 6H_2O \qquad (2)$$

$$2H_2O_2 \longrightarrow 2H_2O + O_2 \qquad (3)$$

Reactions (1) and (2) catalyze (3).

The periodic evolution of oxygen was demonstrated at 60°C in a narrow range of H^+ concentrations.



A REACTION WITH A STEADY STATE

Aqueous solution of H_2O_2, Br_2, Br^- in 0.2N H_2SO_4; titrimetric method; units: minutes and M/l; $\theta = 25°C$ (66, 66.5, 111, 341); *cf.* (342). Simultaneously:

$$H_2O_2 + 2Br^- + 2H^+ \xrightarrow{k_1} Br_2 + 2H_2O \qquad (1)$$

$$H_2O_2 + Br_2 \xrightarrow{k_2} 2H^+ + 2Br^- + O_2 \qquad (2)$$

Addition of (1) and (2) gives:

$$2H_2O_2 \xrightarrow{k} 2H_2O + O_2 \qquad (3)$$

Reaction (1) and (2) proceed independently of each other. If their velocities are equal, $[Br^-]$, $[Br_2]$ and $[H^+]$ are *constant*, and therefore independent of time, and the net result is only the velocity of (3). Measurement in this *steady state* gives:

$$\left.\begin{array}{l} \dfrac{-d[H_2O_2]}{dt} = k[H_2O_2][H^+][Br^-] \\ k = 0.0140 \end{array}\right\} \qquad (4)$$

In the steady state, moreover, the following relation holds:

$$\frac{Br_2}{[H^+]^2[Br^-]^2} = R = 0.20 \qquad (5)$$

The time law for the simultaneous reactions (1) and (2) is:

$$\frac{-d[H_2O_2]}{dt} = k_1[H_2O_2][H^+][Br^-] + k_2\frac{[H_2O_2][Br_2]}{[H^+][Br^-]} \qquad (6)$$

$$\frac{d[Br_2]}{dt} = k_1[H_2O_2][H^+][Br^-] - k_2\frac{[H_2O_2][Br_2]}{[H^+][Br^-]} \qquad (7)$$

With the numerical values:

$$\left.\begin{array}{l} k_1 = 0.0074 \\ k_2 = 0.035 \end{array}\right\} \qquad (8)$$

Addition of (6) and (7) gives:

$$\frac{-d[H_2O_2]}{dt} + \frac{d[Br_2]}{dt} = 2k_1[H_2O_2][H^+][Br^-] \qquad (9)$$

or, for the steady state:

$$\left.\begin{array}{l} \dfrac{d[Br_2]}{dt} = 0 \\ \dfrac{-d[H_2O_2]}{dt} = 2k_1[H_2O_2][H^+][Br^-] \end{array}\right\} \qquad (10)$$

From (10) and (4) it follows that:

$$k = 2k_1 = 2 \times 0.0074 = 0.0148 \qquad (11)$$

in satisfactory agreement with the directly measured value, $k = 0.014$.

It further follows from (7) for the steady state:

$$\frac{[Br_2]}{[H^+]^2[Br^-]^2} = \frac{k_1}{k_2} = \frac{0.0074}{0.035} = 0.21 = R \qquad (12)$$

in agreement with the observed value, $R = 0.20$.

Probable mechanism of reactions (1) and (2):

$$\left.\begin{array}{l} H_2O_2 + H^+ + Br^- \longrightarrow HBrO + H_2O \text{ (rate-determining)} \\ HBrO + H^+ + Br^- \leftrightarrows H_2O + Br_2 \text{ (rapid)} \end{array}\right\} \qquad (1)$$

$$\left.\begin{array}{l} H_2O_2 + HBrO \longrightarrow H_2O + H^+ + Br^- + O_2 \text{ (rate-determining)} \\ Br_2 + H_2O \leftrightarrows HBrO + H^+ + Br^- \text{ (rapid)} \end{array}\right\} \qquad (2)$$

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(For a key to the periodicals see end of volume)

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(140) Dawson, Burton and Ark, *4*, **105**: 1275; 14. (141) Dawson and Powis, *4*, **101**: 1503; 12. (142) Dawson and Wheatley, *4*, **97**: 2048; 10. (143) Dean, *12*, **35**: 605; 13. (144) Dean, *12*, **37**: 331; 14. (145) Delépine, *6*, **23**: 378, 482; 01. (146) De Lury, *50*, **7**: 239; 03. (147) Demierre and Duboux, *42*, **5**: 340; 07. (148) van Dijken, *70*, **14**: 106; 95. (149) Dimroth, *13*, **335**: 1; 04. **338**: 143; 05. **364**: 183; 09. **373**: 336; 10. **377**: 127; 10. **378**: 382; 10. **399**: 91; 13. *9*, **11**: 137; 05. (149.5) Dolch, *Diss.*, Leipzig, 1912.

(150) Drushel, *12*, **33**: 27; 12. **34**: 67; 12. (151) Drushel, *12*, **37**: 514; 14. (152) Drushel, *12*, **39**: 113; 15. (153) Drushel, *12*, **40**: 643; 15. (154) Drushel and Bancroft, *12*, **44**: 371; 17. (155) Drushel and Dean, *12*, **34**: 293; 12. (156) Drushel and Dean, *12*, **35**: 486; 13. (157) Drushel and Hill, *12*, **30**: 72; 10. (157.5) Dumesnil, *34*, **172**: 1043; 21. (158) Dunstan and Mussell, *4*, **99**: 565; 11. (159) Dushman, *50*, **8**: 453; 04.

(160) Dushman, *1*, **43**: 397; 21. (161) Edgar and Wakefield, *1*; **45**: 2242; 23. (162) Eggert, *9*, **23**: 8; 17. **30**: 501; 24. (163) Eggert and Scharnow, *9*, **27**: 455; 21. (164) Enklaar, *70*, **23**: 419; 04. **24**: 419; 05. **25**: 297; 06. **29**: 173; 10. (165) Eucken, *7*, **71**: 550; 10. (166) Euler, *13*, **325**: 292; 02. (167) Euler, *25*, **39**: 2726; 06. (168) Euler and Cassel, *7*, **84**: 371; 13. (169) Euler and Euler, *25*, **38**: 2551; 05. **39**: 36, 39; 06.

(170) Euler and Hedelius, *205*, **107**: 150; 20. (171) Euler and Lövgren, *93*, **147**: 123; 25. (172) Euler, Myrbäck and Rudberg, *19*, **8**: No. 28; 23. (173) Euler and Rudberg, *93*, **127**: 244; 23. (174) Faber and Reid, *1*, **39**: 1930; 17. (175) Fajans, *7*, **73**: 25; 10. (176) Fawsitt, *7*, **41**: 601; 02. (177) Findlay and Hickmans, *4*, **95**: 1004; 09. (178) Findlay and Turner, *4*, **87**: 747; 05. (179) Foerster, *52*, **63**: 141; 01.

(180) Foerster, *9*, **23**: 137; 17. (181) Foerster and Jorre, *52*, **59**: 53; 99. (182) Forster, *50*, **7**: 640; 03. (183) Fraenkel, *7*, **60**: 202; 07. (184) Francis, *54*, **37**: 252; 18. (185) Francis and Geake, *4*, **103**: 1722; 13. (186) Francis, Geake and Roche, *4*, **107**: 1651; 15. (187) Freas and Reid, *1*, **40**: 569; 18. (188) Freundlich and Bartels, *7*, **101**: 177; 22. (189) Freundlich and Krestovnikoff, *7*, **76**: 79; 11.

(190) Freundlich and Neumann, *7*, **87**: 69; 14. (191) Freundlich and Pape, *7*, **86**: 458; 14. (192) Freundlich and Richards, *7*, **79**: 681; 12. (193) Freundlich and Seal, *55*, **11**: 257; 12. (194) Gadamer, *293*, **239**: 294; 01. (195) Garrett and Lewis, *1*, **45**: 1091; 23. (196) Geitel, *52*, **55**: 417, 429; 97. **57**: 113; 98. (197) Gerlinger, *25*, **37**: 3958; 04. (198) Giordani, *36*, **54**: 844; 24. (199) Golblum and Lew, *42*, **10**: 310; 12.

(200) Goldschmidt, *25*, **28**: 3218; 95. (201) Goldschmidt, *9*, **12**: 432; 06. (202) Goldschmidt, *7*, **56**: 1; 06. (203) Goldschmidt, *7*, **60**: 728; 07. (204) Goldschmidt and Bakscht, *13*, **351**: 108; 07. (205) Goldschmidt and Braanaas, *7*, **96**: 180; 20. (206) Goldschmidt and Bräuer, *25*, **39**: 97; 06. (207) Goldschmidt and Bräuer, *25*, **39**: 109; 06. (208) Goldschmidt and Bürkle, *25*, **32**: 355; 99. (209) Goldschmidt and Buss, *25*, **30**: 2075; 97.

(210) Goldschmidt and Ingebrechtsen, *7*, **48**: 435; 04. (211) Goldschmidt and Keller, *25*, **35**: 3534; 02. (212) Goldschmidt and Kepeller, *25*, **33**: 893; 00. (213) Goldschmidt and Larsen, *7*, **48**: 424; 04. (214) Goldschmidt and Merz, *25*, **30**: 670; 97. (215) Goldschmidt and Oslan, *25*, **32**: 3390; 99. **33**: 1140; 00. (216) Goldschmidt and Reinders, *25*, **29**: 1369; 96. (217) Goldschmidt and Salcher, *7*, **29**: 89; 99. (218) Goldschmidt and Scholz, *25*, **40**: 624; 07. (219) Goldschmidt, Storm and Hassel, *7*, **100**: 197; 22.

(220) Goldschmidt and Sunde, *25*, **39**: 711; 06. (221) Goldschmidt and Wachs, *7*, **24**: 353; 97. (222) Griffith and Lewis, *4*, **109**: 67; 16. (223) Grube and Krüger, *7*, **86**: 65; 14. (224) Grube and Nitsche, *92*, **27**: 368; 14. (225) Gruse and Acree, *1*, **39**: 376; 17. (226) Guldberg and Waage, *52*, **19**: 69; 79. (227) Gyr, *25*, **41**: 4308; 08. (228) Gyr, *25*, **41**: 4322; 08. (229) von Halban, *Diss.*, Würzburg, 1909. *7*, **67**: 129; 09.

(230) von Halban, *7*, **72**: 719; 11. **82**: 510; 13. (231) von Halban and Gast, *7*, **91**: 593; 16. (232) von Halban and Hecht, *9*, **24**: 65; 18. (233) von Halban and Kirsch, *7*, **82**: 325; 13. (234) Hantzsch, *25*, **32**: 3066; 99. (235) Hantzsch, *25*, **33**: 2517; 00. (236) Hantzsch and Kalb, *25*, **32**: 3109; 99. (237) Hantzsch and Osswald, *25*, **33**: 278; 00. (238) Hantzsch and Schümann, *25*, **32**: 1691; 99. (239) Hantzsch and Smythe, *25*, **33**: 505; 00.

(240) Harned, *1*, **38**: 1986; 16. (241) Harned, *1*, **40**: 1461; 18. (242) Harned and Pfanstiel, *1*, **44**: 2193; 22. (243) Harned and Seltz, *1*, **44**: 1475; 22. (244) Hawkins, *4*, **121**: 1170; 22. (244.5) Haywood, *4*, **121**: 1904; 22. (245) Hemptinne, *7*, **13**: 561; 94. (246) Henry, *7*, **10**: 96; 92. (247) Hermans, *7*, **113**: 337; 24. (248) Herz and Mylius, *25*, **39**: 3816; 06. (249) Herz and Rathmann, *25*, **46**: 2588; 13.

(250) Herzfeld, *96*, **8**: 132; 21. (251) Heterington and Braham, *1*, **45**: 824; 23. (252) Higgins, *4*, **103**: 1816; 13. (253) Higson, *4*, **119**: 2048; 21. (254) Hinshelwood, *4*, **117**: 156; 20. (254.5) Hinshelwood, *5*, **113**: 221; 26. **114**: 84; 27. (255) Hinshelwood and Burk, *5*, **106**: 284; 24. (256) Hinshelwood and Hartley, *4*, **123**: 1333; 23. (257) Hinshelwood and Prichard, *4*, **123**: 2725; 23. (258) Hinshelwood and Topley, *4*, **125**: 393; 24. (259) van't Hoff, *25*, **10**: 669; 77.

(260) van't Hoff, *B99*, **I**: 217. (261) Holleman, Hartogs and van der Linden, *25*, **44**: 704; 11. (262) Holmberg, *7*, **62**: 726; 08. (263) Holmberg, *25*, **45**: 2997; 12. (264) Holmberg, *7*, **79**: 147; 12. (265) Holmberg, *7*, **80**: 573; 12. (266) Holmberg, *7*, **84**: 451; 13. (267) Holmberg, *52*, **87**: 456; 13. **88**: 553; 13. (268) Holmberg, *519*, **30**: 190, 215; 18. (269) Holmberg, *147*, **5**: No. 11; 19.

(270) Holmberg, *7*, **97**: 134; 21. (271) Holmberg and Hahnel, *485*, **1921**: No. 10. (272) Hudson, *7*, **44**: 487; 03. (273) Hudson, *1*, **29**: 1571; 07. **32**: 889; 10. (274) Hudson and Brown, *1*, **30**: 960; 08. (275) Hudson and Yanovsky, *1*, **39**: 1013; 17. (276) Hunter, *7*, **53**: 441; 05. (277) Jaeger, *70*, **38**: 171; 19. (278) Jellinek, *93*, **49**: 229; 06. (278.5) Jellinek and Jellinek, *7*, **93**: 325; 19. (279) Johansson, *7*, **79**: 621; 12. **81**: 573; 13.

(280) Johansson, *25*, **48**: 1262; 15. (281) Johansson, *215*, **12 II**: No. 8; 16. (282) Johansson and Sebelius, *25*, **51**: 480; 18. (283) Johansson and Sebelius, *25*, **52**: 745; 19. (284) Jones and Lewis, *4*, **117**: 1120; 20. (285) Joyner, *Diss.*, Karlsruhe, 1913. (286) Judson and Walker, *4*, **73**: 410; 98. (287) Kailan, *75*, **115 IIb**: 341; 06. **116 IIb**: 869, 1093; 07. **117 IIb**: 513; 08. (288) Kailan, *57*, **28**: 559; 07. (289) Kailan, *13*, **351**: 186; 07.

(290) Kailan, *7*, **85**: 706; 13. **87**: 619; 14. **89**: 641; 15. (291) Kailan, *7*, **94**: 111; 20. **101**: 63; 22. (292) Kailan, *70*, **41**: 592; 22. (293) Kailan and Oboge, *70*, **43**: 512; 24. (294) Karlsson, *93*, **145**: 1; 25. (295) Kilpi, *7*, **80**: 165; 12. (296) Kilpi, *7*, **86**: 427; 14. (297) Kilpi, *7*, **86**: 641; 14. (298) Kimball and Reid, *1*, **38**: 2757; 16. (299) Kiss, *70*, **42**: 112; 23. **43**: 68, 221; 24.

(300) Kistiakowsky, *7*, **27**: 250; 98. (301) Klemenc, *57*, **35**: 85; 14. (301.5) Klemenc, *57*, **38**: 553; 17. (302) Klemenc, *13*, **433**: 351; 23. (302.5) Klemenc and Pollak, *7*, **101**: 150; 22. (303) Knibbs and Palfreeman, *83*, **16**: 402; 21. (304) Knoblauch, *7*, **22**: 268; 97. (305) Knorr, *25*, **44**: 2767; 11. (306) Knorr, Rothe and Averbeck, *25*, **44**: 1138; 11. (307) Knorr and Schubert, *25*, **44**: 2772; 11. (308) Koelichen, *7*, **33**: 129; 00. (309) Kooij, *7*, **12**: 155; 93.

(310) Krapivin, *42*, **10**: 289; 12. (311) Krapivin, *7*, **82**: 439; 13. (312) Kremann, *57*, **26**: 279; 05. (313) Kremann, *57*, **27**: 607; 06. (314) Kremann, *57*, **27**: 1265; 06. (315) Kremann, *196*, **19**: 289; 13. (316) Kremann, Auer, Oswald and Zoff, *57*, **43**: 345; 22. (317) Kremann and Rösler, *57*, **43**: 359; 22. (317.5) Kremann, Rösler and Penkner, *57*, **43**: 145; 22. (318) Kremann and Wenzing, *57*, **38**: 445; 17. (318.5) Kremann, Zoff and Oswald, *57*, **43**: 139; 22. (319) Kretzschmar, *9*, **10**: 789; 04.

(320) Kruyt and van Duin, *70*, **40**: 249; 21. (321) Küster, *7*, **18**: 161; 95. (322) Küster and Thiel, *Lehrbuch der allg. physik. und theor. Chemie*, **I**: 526. Heidelberg, Winter, 1913. (323) Kuhn, *7*, **114**: 44; 25. (324) Kuhn and Jacob, *7*, **113**: 389; 24. (325) van Laar, *7*, **12**: 742; 93. (326) Lachs, *7*, **73**: 291; 10. (327) Lamb and Fairhall, *1*, **45**: 378; 23. (328) Lamb and Fonda, *1*, **43**: 1154; 21. (329) Lamb and Marden, *1*, **33**: 1873; 11.

(330) Lamble and Lewis, *4*, **105**: 2330; 14. (330.5) Landolt, *25*, **19**: 1317; 86. **20**: 745; 87. (331) Lapworth, *4*, **85**: 30; 04. (332) Lapworth, *182*, **24**: 100; 08. (333) Landolt, *25*, **19**: 1317; 86. **20**: 745; 87. (334) Levy, *7*, **17**: 301; 95. (335) Lewis, *65*, **43**: 257; 07. (336) Lewis, *4*, **113**: 471; 18. (337) Lewkowitsch, *54*, **17**: 1107; 98. (338) Lichty, *50*, **11**: 225; 07. (339) Lievin, *34*, **174**: 868; 22.

(340) Lindner, *57*, **28**: 1041; 07. (340.5) Linhart, *12*, **35**: 283; 13. (341) Livingston, *1*, **48**: 53; 26. (342) Livingston and Bray, *1*, **45**: 2048; 23. (343) Ljunggren, *25*, **56**: 2469; 23. (344) Ljunggren, *205*, **145**: 422; 24. (345) Löwenherz, *7*, **15**: 389; 94. (346) Lueck, *1*, **44**: 757; 22. (347) Lundén, *196*, **14**: 1; 09. (348) Luther and MacDougall, *7*, **62**: 199; 08. (349) Luther and Weigert, *7*, **51**: 297; 05.

(350) McBain and Bolam, *4*, **113**: 825; 18. (351) McMaster and Shriner, *1*, **45**: 751; 23. (352) Madsen, *7*, **36**: 290; 01. (353) Manning, *4*, **119**: 2079; 21. (354) Marshall, Harrison and Acree, *11*, **49**: 369; 13. (355) Martinsen, *7*, **62**: 713; 08. (356) Menschutkin, *13*, **195**: 334; 79. **197**: 193; 79. (357) Menschutkin, *6*, **20**: 289; 80. **23**: 14; 81. **30**: 81; 83. (358) Merrill and Adams, *1*, **39**: 1588; 17. (359) Meyer, *57*, **27**: 1083; 06.

(360) Meyer, *9*, **13**: 186; 07. (361) Meyer, *9*, **13**: 494; 07. (362) Meyer, *7*, **62**: 59; 08. **72**: 117; 10. (363) Meyer, *7*, **66**: 81; 09. (364) Meyer, *7*, **67**: 257; 09. (365) Meyer, *9*, **15**: 506; 09. (366) Meyer, *25*, **44**: 2725; 11. (367) Meyer, *25*, **44**: 2729; 11. (368) Meyer, *13*, **380**: 212; 11. (369) Meyer, *93*, **115**: 203; 21.

(370) Meyer and Hopff, *25*, **54**: 579; 21. (371) Meyer and Schoeller, *25*, **53**: 1410; 20. (372) Moran and Lewis, *4*, **121**: 1613; 22. (373) Morrell and Burgen, *4*, **105**: 576; 14. (374) Müller, *25*, **43**: 2609; 10. (374.5) Müller and Müller, *in B13*. (375) Mumm, *7*, **62**: 589; 08. (376) Myers and Acree, *11*, **50**: 396; 13. (377) Nelson and Beegle, *1*, **41**: 559; 19. (378) Nernst, *7*, **47**: 52, 56; 04. (379) Nernst, *93*, **45**: 126; 05. **49**: 213; 06.

(380) Nernst, *9*, **24**: 335; 18. (382) Nernst and Honmann, *7*, **11**: 352; 93. (383) Nernst and Merriam, *7*, **53**: 235; 05. (384) Nirdlinger, Rogers and Acree, *11*, **49**: 116; 13. (385) Noyes, *7*, **18**: 118; 95. **19**: 599; 96. (386) Noyes, *et al.*, *152*, No. **63**; 07. (387) Noyes and Goebel, *1*, **44**: 2286; 22. (388) Olivier, *70*, **41**: 301; 22. (389) Olivier and Berger, *70*, **41**: 637; 22.

(390) Olsson, *7*, **118**: 107; 25. (391) Olsson, *Die Abhängigkeit der Hydrolysegeschwindigkeit der Ester von der Konstitution.* Lund, 1927. (392) Orton and Jones, *4*, **101**: 1708; 12. (393) Orton, Watson and Bayliss, *4*, **123**: 3081; 23. (394) Osaka, *7*, **35**: 661; 00. (395) Ostwald, *52*, **27**: 1; 83. (396) Ostwald, *52*, **31**: 307; 85. (397) Palme, *93*, **112**: 97; 20. (397.2) Palomaa, *175*, **4A**: No. 2; 14. (397.5) Palomaa, *175*, **5A**: No. 4; 14. (397.8) Palomaa, *175*, **10A**: No. 16; 17. (398) Patterson and McMillan, *25*, **40**: 2564; 07. *4*, **91**: 504; 07. **93**: 104; 08. (399) Patterson and Montgomerie, *4*, **101**: 26; 12.

(400) Pennycuick, *4*, **125**: 2049; 24. (401) Pennycuick, *1*, **48**: 6; 26. (402, 403) von Peskoff and Meyer, *7*, **82**: 129; 13. (404) Pieroni, *36*, **42 I**: 534; 12. (405) Pinnow, *9*, **24**: 21, 270; 18. (406) Poma, *36*, **41 I**: 353; 11. (407) Pomeranz, *57*, **21**: 389; 00. (408) Praetorius, *57*, **26**: 1; 05. **27**: 465; 06. (408.5) Praetorius, *57*, **28**: 767; 07. (409) Price, *7*, **27**: 474; 98.

(410) Price, *4*, **115**: 1354; 19. (411) Pusch, *9*, **24**: 336; 18. (411.5) Ramsperger, *1*, **49**: 912, 1495; 27. **50**: 714; 28. (412) Reicher, *514*, **12**: 78; 85. *70*, **4**: 347; 85. (413) Reicher, *13*, **228**: 257; 85. **232**: 103; 86. (414) Reid, *11*, **24**: 397; 00. **45**: 327; 11. (415) Reynolds and Werner, *4*, **83**: 1; 03. (416) Rheinlander, *4*, **123**: 3099; 23. (417) Rice, Fryling and Wesolowski, *1*, **46**: 2405; 24. (418) Rice and Kilpatrick, *1*, **45**: 1401; 23. (419) Rice and Lemkin, *1*, **45**: 1896; 23. (419.5) Rice and Ramsperger, *1*, **49**: 1617; 27. **50**: 617; 28.

(420) Rideal and Thomas, *4*, **121**: 196; 22. (421) Riesenfeld, *93*, **74**: 48; 12. (422) Riiber, *25*, **55**: 3132; 22. (423) Ringer and Skrabal, *57*, **43**: 507; 22. (424) Rivett, *7*, **82**: 201; 13. **85**: 113; 13. (425) Rivett and Sidgwick, *4*, **97**: 732, 1677; 10. (426) Robertson and Acree, *1*, **37**: 1902; 15. (427) Robertson and Acree, *50*, **19**: 381; 15. (427.5) Roebuck, *50*, **6**: 365; 02. **9**: 727; 05. (428) Rosanoff, *1*, **35**: 173; 13. (429) Rosanoff and Potter, *1*, **35**: 248; 13.

(430) Sachs and Reid, *1*, **38**: 2746; 16. (431) Sagrebin, *7*, **34**: 149; 00. (432) Sand and Kaestle, *93*, **52**: 101; 07. (433) Scatchard, *1*, **43**: 2387; 21. **45**: 1580; 23. (434) Schierz, *1*, **45**: 447, 455; 23. (435) Schoorl, *70*, **22**: 31; 03. (436) Schreiner, *93*, **116**: 102; 21. (437) Schümann, *25*, **33**: 527; 00. (438) Schwicker, *7*, **16**: 303; 95. (439) Segaller, *4*, **103**: 1154, 1421; 13. **105**: 106, 112; 14.

(440) Selle, *7*, **104**: 1; 23. (440.5) Senter, *7*, **70**: 511; 10. (440.8) Senter, *25*, **45**: 2318; 12. (441) Shields, *7*, **12**: 167; 93. (442) Shroder and Acree, *4*, **105**: 2582; 14. (443) Sidgwick and Moore, *4*, **95**: 889, 899; 09. (444) Skrabal, *57*, **32**: 167; 11. (445) Skrabal, *57*, **32**: 185; 11. (446) Skrabal, *57*, **33**: 99; 12. (447) Skrabal, *57*, **35**: 1157; 14. (448) Skrabal, *9*, **21**: 461; 15. (449) Skrabal, *57*, **37**: 495; 16.

(450) Skrabal, *57*, **38**: 29; 17. (451) Skrabal, *57*, **38**: 159; 17. (452) Skrabal, *57*, **38**: 305; 17. (453) Skrabal, *57*, **39**: 741; 18. (454) Skrabal, *57*, **43**: 493; 22. (455) Skrabal, *9*, **28**: 224; 22. (456) Skrabal, *9*, **33**: 322; 27. (457) Skrabal and Airoldi, *57*, **45**: 13; 24. (458) Skrabal and Baltadschiewa, *57*, **45**: 19, 95; 24. (459) Skrabal and Belavić, *7*, **103**: 451; 23.

(460) Skrabal and Bilger, *7*, **130**: 29; 27. (461) Skrabal, Brunner and Airoldi, *7*, **111**: 109; 24. (462) Skrabal and Eger, *7*, **122**: 349; 26. (463) Skrabal and Gitschthaler, *7*, **128**: 459; 27. (464) Skrabal and Gruber, *57*, **37**: 535; 16. (465) Skrabal and Hermann, *57*, **43**: 633; 22. (466) Skrabal and Hohlbaum, *57*, **37**: 191; 16. (467) Skrabal and Hugetz, *57*, **47**: 17; 26. (468) Skrabal and Matievic, *57*, **39**: 765; 18. (469) Skrabal and Matievic, *57*, **45**: 39; 24.

(470) Skrabal and Mirtl, *7*, **111**: 98; 24. (471) Skrabal and Mrazek, *57*, **39**: 495; 18. (472) Skrabal and Mrazek, *57*, **39**: 697; 18. (473) Skrabal and Muhry, *57*, **42**: 47; 21. (474) Skrabal, Pfaff, and Airoldi, *57*, **45**: 141; 24. (474.5) Skrabal and Raith, *57*, **42**: 245; 22. (475) Skrabal and Rieder, *9*, **30**: 109; 24. (476) Skrabal and Ringer, *57*, **42**: 9; 21. (477) Skrabal and Sawiuk, *7*, **122**: 357; 26. (478) Skrabal and Schiffrer, *7*, **99**: 290; 21. (479) Skrabal and Singer, *57*, **40**: 363; 19.

(480) Skrabal and Singer, *57*, **41**: 339; 20. (481) Skrabal and Sperk, *57*, **38**: 192; 17. (482) Skrabal and Weberitsch, *57*, **36**: 211; 15. (483) Skrabal and Weberitsch, *57*, **36**: 237; 15. (484) Skrabal and Zahorka, *57*, **46**: 559; 25. (485) Skrabal and Zahorka, *57*, **48**: 459; 27. (486) Skrabal and Zahorka, *9*, **33**: 42; 27. (487) Skrabal and Zlatewa, *57*, **47**: 39; 26. (487.5) Skrabal and Zlatewa, *7*, **119**: 305; 26. (488) Slator, *7*, **45**: 513; 03. (489) Sluiter, *70*, **24**: 365; 05.

(490) Sluiter, *70*, **24**: 372; 05. (491) Smith, *7*, **102**: 54; 22. (491.5) Smith, *1*, **47**: 1862; 25. (492) Smith and Paterson, *4*, **1926**: 940. (493) Snethlage, *7*, **90**: 1; 15. (494) Spitalsky, *93*, **53**: 184; 07. (495) Spitalsky, *93*, **54**: 265; 07. (496) Spitalsky, *93*, **56**: 72; 07. **69**: 179; 11. (497) Spohr, *52*, **33**: 265; 86. (498) Spohr, *7*, **2**: 194; 88. (499) Stieglitz and Curme, *25*, **46**: 911; 13.

(500) Stern, *7*, **50**: 513; 05. (501) Stock and Bodenstein, *25*, **40**: 570; 07. (502) Stock, Gomolka and Heynemann, *25*, **40**: 532; 07. (503) Sudborough and Gittins, *4*, **93**: 210; 08. **95**: 315; 09. (504) Sudborough and Thomas, *4*, **91**: 1033; 07. (504.5) Sudborough and Turner, *4*, **101**: 237; 12. (505) Tassilly, *34*, **157**: 1148; 13. **158**: 335, 489; 14. (506) Tassilly, *27*, **27**: 19; 20. (507) Taylor, *1*, **37**: 551; 07. (508) Taylor, *147*, **2**: No. 34; 13. (509) Taylor and Close, *1*, **39**: 422; 17.

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(560) Wulf, Daniels and Karrer, *1*, **44**: 2398; 22. (561) Wunderly, *7*, **112**: 175; 24. (562) Yamasaki, *1*, **42**: 1455; 20. (563) Young, *1*, **23**: 119; 00. **24**: 297; 01. (564) Abel and Schmid, *7*, **136**: 430; 28. (565) Baur, *7*, **140**: 194; 29.

THE KINETICS OF BIOCHEMICAL REACTIONS

J. TEMMINCK GROLL

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INTRODUCTION

The following standard works and monographs, used in composing these tables, should be consulted in the first instance for further information on this subject. The periodical literature is so extensive that only a very small part of it could be cited here.

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SYMBOLS

For explanation of equations and symbols, *v.* p. 115.

HYDROLYSIS OF FATS

LIPASE, RICINUS

Time.—According to Nicloux (127) and Taylor (162) the reaction is monomolecular. According to Connstein (35), $x/\sqrt{t} = k$. In a mixture of 4 g of 0.1% H_2SO_4 + 5 g ric. seed + 6.5 g ric. oil he finds:

t (min)	15	30	45	60	90	150	210	330	1620
x	12	20	30	33	41	54	59	68	81
$x/\sqrt{t}$	3.11	3.65	4.47	4.26	4.32	4.51	4.07	3.74	2.01

Using 0.02 g ric. lip. + 1 g triolein + 1 cm³ 0.01*N* acetic acid, shaken at 20°C, Jalander (96) finds $\left(k_1 = \frac{10^4}{t} \log_{10} \frac{a}{a - x}\right)$:

t (min)	10	20	30	60	120	240
cm³ 0.1*N* NaOH	6.76	11.55	15.93	18.85	26.18	28.54
% split	20.39	34.87	48.05	56.86	78.97	86.54
k_1	100	93	93.9	60.6	56.2	35.7
$x/\sqrt{t}$	6.4	7.8	8.7	7.3	7.2	5.7

Enzyme Concentration (= E).—Jalander (96) finds:

10^3E	cm³ 0.1 *N* NaOH	% split	%/E	10^3E	cm³ 0.1 *N* NaOH	% split	%/E
1	1.68	4.46	4.46	10	15.63	41.57	4.16
2	3.40	9.04	4.52	15	19.96	53.08	3.54
3	5.20	13.85	4.65	20	22.18	58.99	2.99
4	6.70	17.82	4.45	25	23.05	61.30	2.41
5	8.31	22.10	4.40				

Temperature.—Reaction checked at 50°C (35).

pH.—Optimum at ±5 (76), checked at 3.

Activation.—0.2% $MnSO_4$ activates strongly (16, 35). Bile salts (38) and saponin decrease action. For neutral salts, *v.* (58).

Reversibility.—*v.* (96, 162); *v. also* (59, 68, 91). Jalander (96) finds at 20°C, with 2 min shaking 5 times daily:

Splitting of ester 0.01 g dry ric. lip. + 1.0 g triolein + 1 cm³ 0.01 *N* acetic acid			Synthesis of ester 0.01 g dry ric. lip. + 0.957 g oleic acid + 0.104 g glycerol + 1 cm³ 0.01 *N* acetic acid		
Days	cm³ 0.1 *N* alkali	% oil split	Days	cm³ 0.1 *N* alkali	% oleic acid bound
15	29.51	89.02	15	30.31	11.16
30	29.30	88.37	30	30.35	11.04

LIPASE, PANCREATIC

Time.—Using 10 cm³ olive oil + 3.9 cm³ 0.1 *N* alkali + 0.25 cm³ *N* $CaCl_2$ + 1 cm³ pancr. extr. (hog), Kanitz (98) found:

t (min)	70	140	288	405	1455
x/t	0.131	0.088	0.065	0.057	0.023
$x/\sqrt{t}$	1.1	1.04	1.12	1.15	0.90

Enzyme Concentration (E).—Velocity proportional to E (100).

Temperature (100).

°C	0		10		20		30
$k_{\theta+10}/k_\theta$		1.50		1.34		1.26	
A (cal.)		6300		4800		4100	

pH.—Optimum at 8.3–9 (145).

Activation.—For neutral salts, *v.* (61, 98, 123, 132, 164).

LIPASE OF TISSUE EXTRACTS

Spontaneous increase of activity (128). Ester-hydrolyzing action of tissue and tumor extracts after different time-intervals, preserved at room temperature.

Ester / Days	Whole rats						Rabbit livers	
	3.5 days old			22 days old			28 days pregnant	
	0	*8*	*16*	*0*	*3*	*9*	*0*	*15*
Phenyl acetate	4.30	4.03	4.08	6.06	5.94	5.97	4.56	2.88
Glyceryl triacetate	2.72	2.94	2.92	3.71	3.35	3.28	3.06	2.78
Methyl butyrate	1.31	1.73	1.68	2.62	3.55	3.20	3.63	3.72
Benzyl acetate	0.79	0.94	0.88	1.26	1.68	1.67	1.78	1.96
Ethyl acetate	0.78	0.83	0.81	1.24	1.39	1.40	1.23	1.48
Methyl acetate	0.73	0.74	0.68	1.05	1.16	1.05	1.60	1.80
Ethyl butyrate	1.40	1.75	1.62	2.69	3.55	3.37	2.64	3.05
Methyl benzoate	0.23	0.20	0.21	0.68	0.61	0.61	0.82	0.82
Ethyl benzoate	0.36	0.36	0.33	0.77	0.82	0.82	0.54	0.55
Isobutyl acetate	0.80	0.94	1.00	1.33	1.70	1.66	1.79	1.88

HYDROLYSIS OF CARBOHYDRATES

Starch-Splitting Enzymes

AMYLASE, MALT

Time.—With this and also with the other amylases, no concordant data are to be found, in consequence of the complicated structure of the starch molecule.

According to Brown (25), k of the monomolecular reaction increases rapidly with time.

According to Henri (83) and Euler (51), the monomolecular k is approximately constant; according to Philoche (134, 135), only after 30% of the starch is split.

Substrate Concentration; v. also (7, 39, 44, 74, 102, 105, 107, 129, 136, 153, 155, 156, 166).

% starch	1	1.5	2	2.5	3
g maltose in 1 hr	0.24	0.30	0.338	0.397	0.397

AMYLASE, TAKA (ASPERGILLUS ORYZAE)

Time.—At 31.5°, 1% starch and taka-diastase 1:20 000, Philoche (134) found:

t_1 (min)	21	51	113	224	390
x/a	0.06	0.11	0.15	0.26	0.36
10^4k	12.3	10.0	6.2	5.8	5.0

pH.—Optimum at 4.8 (152).

Activation.—Neutral salts, no definite activation (147, 152). NaCl activates above 0.1 N (174).

AMYLASE, YEAST

pH.—Optimum at 4.5 to 6 (72).

AMYLASE, SALIVA

Time.—Should be monomolecular according to Taylor (163).

Temperature.—$k_{\theta+10}/k_\theta$, (20–30°) = 2. A = 12 300 (168).

Enzyme Concentration.

E	1	2	3	5	Lit.
% maltose in 10 min	0.077	0.150	0.202	0.385	(55)

pH.—Optimum at 6.0 to 6.4 (40, 72, 75, 115, 142).

Neutral Salts.—(71).

AMYLASE, PANCREATIC

Time.—(83, 101, 133, 134).

pH.—Optimum = 5–7 (Hog); = 6–7.5 (Ox); = 6–8 (Man) (72).

Hydrolysis of Raffinose

RAFFINASE, YEAST

Time.—According to Willstätter (172), $\left(k = \frac{10^5}{t} \log_{10} \frac{a}{a - x}\right)$:

Min	First experiment		Second experiment	
	% split	k	% split	k
10	6.9	310	8.9	404
20	14.5	340	18.5	445
30	21.6	352	24.4	404
45	31.3	362	32.6	381
60	39.4	362	40.5	376
80	48.4	359	49.2	367
110	60.0	362	59.4	356
150			69.5	344
160	72.1	346		
200			77.5	324
220	82.1	340		
260			85.9	327
∞	100.0		100.0	

Enzyme Concentration (172); *cf.* (11).

E (cm³ in 25)	0.25	0.5	1.0	2.5	5.0
t (min)	400	200	100	40	20
% split	24.8	25.6	25.6	26.2	26.2

pH.—Per cent split at different pH.

pH	1.5	2.5	3.0	4.0	5.0	6.0	6.5	7.0	7.5	8.0
%	47.5	55.8	58.9	63.3	64.1	58.7	50.5	37.0	14.4	9.4

RAFFINASE, ALMONDS

Time.—Using a 2.3% solution, and 1 g emulsion, at 30°, and pH = 4.2, Willstätter (171) found monomolecular k:

t (hr)	1	2.5	6	9	22.5	26	30.5
% split	3.5	8.5	18.0	25.6	55.2	60.5	66.0
10^4k	351	355	330	328	350	356	352

pH.—Optimum at 4.1 (171).

Hydrolysis of Sucrose

INVERTASE, YEAST

Time.—$\left(k = \frac{10^5}{t} \log_{10} \frac{a}{a - x}\right)$ according to Hudson (92):

t (min)	30	60	90	110	130	150
k	558	530	539	534	559	533

According to Michaelis (117):

t (min)	0.5	21	60	130	190.2	246.0
x	0.010	0.389	1.074	2.205	3.004	3.590
10^5k		1.45	1.51	1.64	1.71	1.76

According to Nelson and Vosburgh (126):

t (min)	35	80	159.5	265	425	785
% inversion	9.42	21.02	39.66	60.02	80.04	94.88
10^5k	1.23	1.28	1.38	1.50	1.65	1.64

Concentration of Enzyme and Substrate.—Relation between time for 40% inversion (t_{40}) and concentration of sucrose, (C_s) at pH = 5.5 (126):

C_s g/l	cm³ invertase, y	t_{40}	$\frac{t_{40} \times y}{C_s}$
50	2	47.5	19.0
50	1	93	18.6
100	2	79	15.8
100	1	163	16.3
200	2	175	17.5
200	1	376	18.8

Temperature.—According to Kjeldahl (103) calculated by Herzog; *cf.* (123.1).

°C	0	18	30	40	45
k	17	60	113	179	228
A	11 100	9 300	8 800	9 600	
$k_{\theta+10}/k_\theta$	2.01	1.69	1.58	1.62	

According to Tammann (160); *v. also* Euler and Laurin (48).

°C	0	21	30.1	39.8	50
k	18	120	163	216	302
A	14 500	6 000	5 500	6 600	
$k_{\theta+10}/k_\theta$	2.47	1.40	1.34	1.39	

pH.—Optimum: 3.5–5.5 at 52° (158) and at 22° (117).

Activation.—Neutral salts (28, 57); salts of heavy metals (52); various organic substances (53); *v. also* (14, 17, 24, 29, 30, 31, 32, 33, 47, 50, 84, 92, 120, 124, 125, 126, 131).

INVERTASE, BANANA

Time.—No satisfactory data (62).

pH	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5
Action	183	481	489	478	458	375	135	52

For effect of aging, *v.* (111); *v. also* (63).

Hydrolysis of Maltose

Maltase, Yeast

Time.—No concordant results, *v.* (9, 87, 107, 173). According to Willstätter the reaction is monomolecular (173).

t (min)	10	20	30	40	60	80	100	150	200	300
% split	19.2	26.9	33.8	37.7	44.0	49.0	53.2	61.2	66.4	75.0

Enzyme Concentration.—(173).

E	2	5	10
t (min)	150	60	30
% split	34.2	34.4	34.5

Temperature.—According to Lintner and Kröber (108), calculated by Herzog; *cf.* (130).

°C	10	20	30	40
Velocity	1	1.9	2.74	3.58
A	10 600	6 500	5 100	
$k_{\theta+10}/k_\theta$	1.90	1.44	1.28	

pH.—Optimum at 6.1–6.8, with "untergährige Bierhefe," brewers' bottom yeast (122).

Activation.—Neutral salts, no effect except Ca which decreases action.

Maltase, Taka Diastase

pH.—Optimum at *ca.* 4 (97); at 4.1 (8); *v. also* (34).

Hydrolysis of Lactose

Lactase, Almond

Time.—With 0.7% solution, 0.5 g emulsin, pH at 4.4, 30°C, monomolecular k (171); *v. also* (9, 10).

t (hr)	4	7	21	24	30	46
% split	15	24	55	61	69.5	85
10^4k	410	390	380	390	396	410

pH.—(171).

pH	3.2	3.8	4.4	4.9	6.0	7.0	8.0
% split	30	39	44	41	30	8.5	2.5
10^3k	9.7	13.4	15.7	14.3	9.7	2.3	0.7

Hydrolysis of α-Glucosides

α-Glucosidase, Yeast

Time.—2.7% solution of glucoside at 30°C (174).

t (min)	10	20	40	60	100	160	240	340
% split	7.6	12.3	20.4	26.7	35.9	45.9	53.1	60.2

Enzyme Concentration.

E (cm³ in 50 cm³)	1	2	5	10
t (min)	800	400	160	80
% split	32	32	31.4	31.4

$E \times t$ = *ca.* constant (174).

pH.—Hydrolysis of maltose and of α-methylglucoside at pH = 6.0 to 7.8. T. V. = time value of yeast extract (174):

pH	Maltose		Glucoside	
	% split	T. V.	% split	T. V.
6.0	43.0	86	32.7	142
6.4	42.8	87	33.3	137
6.8	42.7	87	32.7	142
6.8	42.7	87	28.2	280
7.2	41.4	93	24.5	340
7.8	40.3	99	24.5	340

Reversibility.—Influence of alcohol concentration (C_A) on yield, % bound; 1% solution of glucose; aqueous extract of yeast at 16°C (20):

C_A	days	%	C_A	days	%	C_A	days	%	C_A	days	%
0	0	0	10	8–14	20.6	20	31–35	32.6	30	14–20	14.4
2	1–4	6.9	12	8–14	22.9	22	31–35	31.7	32	1–4	8.2
4	1–4	10.0	14	8–14	26.7	24	28–31	30.0	34	1–4	
6	1–4	14.0	16	14–20	29.7	26	24–28	28.7	36		5.2
8	8–14	19.4	18	20–24	31.2	28	14–20	25.6			

Synthesis of α-Methyl-α-glucoside

Alcohol Concentration (C_A).—1% solution of glucose, extract of dried yeast, 16–18°C (20).

C_A g/100 cm³	10	12	14	16	18	20	22	24
Days	16–20	18–22	18–22	18–22	35–38	35–38	42–48	31–35
% bound	45.0		50.2	54.0	59.0	59.6	61.1	54.0

Quantity of Enzyme.—Solution of 1 g glucose and 16 g methyl alcohol in 100 cm³. Yeast powder:

Yeast, g	%	Yeast, g	Days	%	Yeast, g	Days	%
0.025	3.01	0.15	30–40	11.56	0.50	40–43	50.43
0.05	3.59	0.20	60–80	21.86	1.00	22–25	53.15
0.10	6.41	0.25	120–140	34.20	2.00	11–15	53.15

Quantity of Glucose.—18 g methyl alcohol in 100 cm³; aqueous extract of yeast (20).

g Gl./100 cm³	1	2	5	10	15
t (days)	22–31	30–40	60–70	150–180	180–210
Gl. bound %	57.5	57.8	54.7	52.4	44.6

Hydrolysis of β-Glucosides

Emulsin, Almond

Time.—0.8% glucoside (β-methylglucoside); 0.1 g emulsin pH = 4.4, 30°C (171).

Hr	2	16	19	23	26	41	48
% split	7.1	48.35	57.45	62.0	65.4	81.0	84.2
10^4k	370	410	450	420	410	400	380

Enzyme Concentration.—(161, 171).

Enzyme	1	2	4	Lit.
Initial velocity	1	2.3	3.9	(169)

pH.—Optimum at 4.7–5.1 (171).

Temperature.—According to Tammann (161), calculated by R. Herzog.

°C	0	20.5	30	40.2	50.3
k	1	5.6	14.0	21.0	30.5
A	13 400	17 200	7 600	7 300	
$k_{\theta+10}/k_\theta$	2.31	2.62	1.49	1.44	

Reversibility.—Synthesis of β-ethylglucoside. Solution of 1 g glucose in 100 cm³; 0.4 g emulsin (21):

Alcohol	Reaction duration, days	Glucose not bound	Alcohol	Reaction duration, days	Glucose not bound	Alcohol	Reaction duration, days	Glucose not bound
100	No reaction		80	10–15	0.345	30	5–10	0.767
95	55–58	0.140	60	10–15	0.553	20	<5	0.844
90	30–35	0.203	50	10–15	0.648	10	<5	0.894
85	20–25	0.300	40	5–10	0.691			

Synthesis of β-Ethylgalactoside (23)

Alcohol Concentration.—C_A in g/100 cm³:

C_A	% galactose bound after, months			
	1	4	8	9½
20	15.92	19.70	27.77	29.47
30	22.16	29.92	37.31	38.52
40	23.32	33.40	39.06	39.64
50	28.57	38.10	45.84	45.36
60	36.29	47.32	49.24	49.90
70	56.75	57.28	59.41	59.06
80	59.66	67.55	69.20	69.20

v. also (22, 82, 93).

HYDROLYSIS OF PROTEINS

Pepsinases

PEPSIN, GASTRIC

Enzyme Concentration.—1 g globulin and 5 cm³ 5% HCl in 100 cm³ for 16 hr at 37.5°C; x = constant × $E^{1/2}$, where x is the rotation of the peptone and E the pepsin concentration (148). According to Arrhenius (12) a more accurate relation is $Ek = \frac{a}{t}\log\frac{a}{a-x} - \frac{x}{t}$.

Time.—E × *t* = *ca.* constant, where *t* is the time. Accuracy ± 10%. *See further* (12).

Temperature.—(88).

°C	14		19.4		24.2		28.9		35.5
% split	0.95		2.14		3.67		4.9		7.7
A		25 400		19 600		11 100		12 800	
$k_{\theta+10}/k_\theta$		4.5		3.08		1.85		1.98	

v. also (4, 6, 26, 73, 90, 104, 138, 149, 151, 157, 165).

pH.—Optimum at 1.5–2 (158).

Tryptases

TRYPSIN, PANCREATIC

Time.—According to Arrhenius (12), who calculated experiments of V. Henri and des Bancels (85), x = $kt^{1/2}$ where x is the increase in conductivity.

Soln.	t(min)	10	20	30	40	55
4% gelatin	x(obs.)	27.3	44	53	58.7	65.7
44.3°C, k = 7.37	x(calc.)	29.3	41.5	50	58.7	68.8
Casein in 2% $NaHCO_3$ soln.	x(obs.)	24	36	41	42	44
44°C, k = 7.59	x(calc.)	24	34	42	48	54

Enzyme Concentration.—t_1, t_2, t_3 = times for same decomposition.

E	t_1	$t_1 \times E$	t_2	$t_2 \times E$	t_3	$t_3 \times E$
0.5	37	18.5	89	44.5	720	360
1	19	19	45	45	480	480
2	10	20	24	48	274	548
2.5	7.5	18.8	19	47.5	245	613
4	4.5	18	13	52	226	904

Temperature.—(130).

°C	19.4		25.2		29.8		35.8
% split	3.3		7.1		9.5		18.2
A		23 000		11 400		20 200	
$k_{\theta+10}/k_\theta$		3.75		1.88		2.96	

pH.—Trypsin from pancreatin "Rhenania" acting on "pepton Riddel" (118); *cf.* (140, 141), "Sörensen-method."

pH	3.65	4.25	4.78	5.78	6.49	6.98
Activity	0	0.028	0.075	0.31	0.58	0.78

pH	7.01	7.02	7.68	9.17	11.26
Activity	0.84	0.86	1.00	0.87	0.085

v. also (18, 116).

TRYPSIN, MALT

Temperature.—(170).

°C	15		25		36		45
v	0.42		1.42		3.80		5.34
A		20 900		16 500		7 400	
$k_{\theta+10}/k_\theta$		3.38		2.45		1.46	

Peptases

EREPSIN, HOG INTESTINE

Time.—0.10 glycylglycine; 0.04 *N* NaOH; 5 g erepsin prep. in 100 cm³; 37°C. $k_1 = \frac{10^3}{t}\log_{10}\frac{a}{a-x}$. Conductivity method (43).

t(min)	0	7	13	20	28	36
$10^3(a-x)$	930	837	763	690	620	550
k_1		6.54	6.60	6.48	6.30	6.33

Temperature.—(2).

°C	25		35		45
v	1		2.35		3.5
A		14 800		8 600	
$k_{\theta+10}/k_\theta$		2.25		1.56	

v. also (1, 3, 5).

EREPSIN, YEAST JUICE

Time and pH.—0.4 g glycyl-*l*-leucine in 10 cm³ H_2O + 20 cm³ phosphate + 2 cm³ yeast juice. pH electrometr.; 25°C. For the formol titration are taken 5 cm³ a = 62.5 mg. $k_0 = 10^4x/t$, $k_1 = \frac{10^4}{t}\log_e\frac{a}{a-x}$, $k_2 = \frac{10^4x}{t^{1/2}}$ (66).

pH	t(min)	x, mg	k_0	k_1	k_2
6.27	10	10.5	10.5	184	
	20	22.4	(11.2)	(222)	
	30	29.9	9.9	217	
	40	38.0	9.5	234	
7.37	10	15.2	25.6	279	25.6
	20	25.8	30.6	266	30.6
	30	35.2	34.1	276	34.1
	40	41.6	34.9	273	34.9
8.41	10	23.5		472	39.5
	20	37.2		401	44.3
	30	44.5		415	43.2
	40	49.3		389	41.2
9.33	10	11.6		205	36.7
	20	18.4		174	41.2
	30	25.4		174	24.6

MILK COAGULATION BY RENNET

Time and Concentration of Rennet.—Time of curdling × concentration of rennet = constant (±*ca.* 30%), with calf rennet, not with that of swine or man (112).

Temperature.—(66).

°C	25		30		35		40
v	1		1.69		3.15		5.40
A		18 600		22 300		20 800	
$k_{\theta+10}/k_\theta$		2.86		3.32		2.94	

pH.—Optimum at 5 (36). In the presence of Ca salt, optimum at 6–6.4 (119).

Calcium Salts.—For effect, *v.* (146); *v. also* (65, 66, 77, 89, 95, 106, 139, 159).

HYDROLYSIS OF UREA

UREASE, SOY-BEAN

Time.—According to (15), $m \times t = \frac{nc}{0.434} \log_{10} \frac{1}{1-y} + ay.$

x = concentration urea (g in 100 cm³)
c = concentration H-ions (g in 100 cm³)
n = coefficient of absorption (1 g H-ions absorbs n times the radiation absorbed by 1 g urea)

$$y = \frac{a - x}{a}$$

$$m = \text{velocity constant} = \frac{0.0327 \log_{10} \frac{1}{1-y} + 0.01y}{t}$$

t (min)	20	30	50	70	90	110
cm³ 0.1 N NH_3	1.78	2.58	3.68	5.08	5.88	6.51
y	0.223	0.323	0.460	0.635	0.735	0.814
10^6m	290	292	267	295	291	291

pH.—(15).

pH	5.84	6.13	6.40	6.67	7.0	7.21
10^5m	20.5	22.1	26.7	35.4	51.3	67
pH	7.52	7.64	7.80	8.03	8.13	8.65
10^5m	75.2	70.3	62.3	47.3	41.7	24.4

Concentration of Urea.—cm³ of $\frac{1}{50}$ N NH_3 formed in 120 min in 12 cm³ (15); *v. also* (46, 60, 69, 70, 109, 110, 113, 114, 143, 144, 167).

C_U \ pH	5.83	6.68	6.81	6.89	7.14	7.47	7.83	8.10
0.03	0.068	0.58	0.95	1.2	1.65	3.2	3.2	2.9
0.05		0.9	1.4	1.7	2.25	3.45	3.75	3.2
0.08	0.164	1.3	1.9	2.3	2.7	4.05	3.55	3.2
0.1	0.21	1.6	2.15	2.5	3	4.15	4.1	3.4
0.2	0.375	2.3		3.4	3.55	4.65	4.3	3.7
0.5	0.85	3.3	3.9	4.3	4.1	5	4.5	3.8
1	1.5	3.9	4.5	4.65	4.3	5.05	4.25	3.9
2	2.75	4.45	4.9	5.2	4.5	5.15	4.75	4.1
4	3.2	4.8	5.15	5.4	4.45	5.25	4.6	3.9
6	4.15	4.85	5.2	5.3	4.45	4.85	4.35	3.65
8	4.65	4.8	5	5.15	4.25	4.6	4	3.25

DECOMPOSITION OF PEROXIDES

CATALASE, YEAST

Time.—Values of $434.3k$ (94).

25°C, $\frac{1}{90}$ mole H_2O_2

t (min)	0	5	10	15	20	25	30
cm³ $KMnO_4$	41.8	31.5	23.7	17.9	13.5	10.2	7.6
$434.4k$		24.57	24.67	24.55	24.54	24.50	24.69

0°C, $\frac{1}{33}$ mole H_2O_2

t (min)	0	5	10	20	30	40	60
cm³ $KMnO_4$	48.4	38.1	30.1	18.7	11.6	7.2	2.8
$434.4k$		20.78	20.62	20.65	20.67	20.68	20.62

Enzyme Concentration.—$k = 0.183E^{0.366} \pm$ *ca.* 1%.

Living Yeast.—Splitting of H_2O_2 by living yeast, pH = 6.8; 0°C, according to Euler (45).

A = 0.1 g of yeast in 100 cm³ 0.4% Na phosphate; of this are taken 50 cm³ + 50 cm³ 0.02 N H_2O_2

B = 0.2 g of yeast in 100 cm³ 0.4% Na phosphate; of this are taken 50 cm³ + 50 cm³ 0.02 N H_2O_2

C = 0.3 g of yeast in 100 cm³ 0.4% Na phosphate; of this are taken 50 cm³ + 50 cm³ 0.02 N H_2O_2

Living Yeast.—(*Continued*)

	A		B		C	
Min	cm³	10^4k	cm³	10^4k	cm³	10^4k
0	5.2		5.2		5.2	
15	5.0	11	4.8	23	4.5	42
30	4.8	11	4.4	24	3.7	49
45	4.7	10	4.1	23	3.2	47
60	4.5	10	3.8	21	2.8	45

Activation.—The activating action of toluene, chloroform, phenol and thymol on the H_2O_2-splitting capacity of living yeast (45); *v. also* (135).

A: 0.2 g of yeast in 100 cm³ water, saturated with 0.5 cm³ toluene, chloroform, etc., 50 cm³ of this + 50 cm³ 0.0185 N H_2O_2, pH = 6.2.

B: The same, without toluene, chloroform, etc., pH = 6.8.

Toluene

t (min)		0	10	20	30	40	50	60
A	cm³	5.2	4.8	4.4	4.0	3.8	3.5	3.3
	10^4k		35	36	38	34	34	33
B	cm³	5.2		4.9	4.7	4.6	4.5	4.4
	10^4k			13	13	13	13	12

Chloroform

t (min)		0	20	30	40	.50
A	cm³	5.6	2.7	1.8	1.4	0.9
	10^4k		158	164	150	158
B	cm³	5.6	5.05	4.8	4.6	4.2
	10^4k		22	22	21	25

Thymol, cm³ of O_2 15°C, humid

t (min)		15	30	60	90	105
cm³	A	12	14	22	28	30
	B	11	13	16	20	21

Phenol =	A, 0.0	B, 0.5 g	B, 2 g
Min	pH = 7	pH = 6.9	pH = 6.6
20	7.5	9.0	14.2
40	9.5	14.5	18.6
60	11.5	18.3	21.5
80	13.5	19.5	22.5

CATALASE, BLOOD (HEMASE)

Time.—Monomolecular k (150).

t (min)	0	5	10	20	30	50
H_2O_2 concn.	46.1	37.1	29.8	19.6	12.3	5.0
$434.3k$		19.0	19.2	19.0	19.3	19.4
Enzyme concentration	E	3	6	8	24	
	v	28	58	72	230	
	v/E	9.33	9.66	9.00	9.6	

Enzyme Concentration.—(54).

E	v	$v/E^{1/2}$	E	v	v/E
100	100	10.0	20	40.3	2.01
50	76.7	10.8	15	32.7	2.18
40	63.8	10.06	10	22.6	2.26
30	57.4	10.50	6	16.6	2.76
			4	9.5	2.37
			2	3.52	1.76

Temperature.—Herzog.

°C	0	10	$k_{\theta+10}/k_\theta$
v_I	0.0120	0.180	±1.5
v_{II}	0.192	0.0294	

OTHER CATALASE

Liver (121, 137).
Milk (56).
Fat tissue (13).
Boletus scaber (42).
Apple-leaf tissue (81).

ALCOHOLIC FERMENTATION

Time.—1 l of a 1.136 N dextrose solution with 1.2 g acetone yeast (dead). 24.5°C. k_1 = monomolecular k; $k_s = \frac{1}{2t} \log_e \frac{a+x}{a-x}$ (86).

t (min)	0	120	240	1200
a − x	1	0.961	0.922	0.673
$434.3 \times 10^3 k_1$		144	147	143
$434.3 \times 10^3 k_s$		141	141	123

t (min)	1440	1740	2690	3000
a − x	0.612	0.549	0.396	0.354
$434.3 \times 10^3 k_1$	148	149	149	150
$434.3 \times 10^3 k_s$	123	121	120	111

t (min)	0	200	301	465	561	923
a − x	520	493	477	454	443	407
$10^4 k_1$ (41)		1.16	1.25	1.26	1.24	1.15

Living yeast cells (67)

t (min)	0	34	68	86	136	156	182	215
°Rotation	36.4	34.2	31.9	30.7	27.7	26.7	24.7	23.4
$10^5 k$		154	158	157	156	152	156	151

t (min)	246	273	304	330	404	452	572
°Rotation	21.6	20.3	18.8	17.2	14.0	12.0	8.4
$10^5 k$	152	151	151	154	152	155	154

Substrate Concentration.—20 cm³ yeast juice in presence of toluene at 22°C (27).

Sucrose:		CO_2 in g after:		
Wt.	%	6 hr	24 hr	96 hr
2.2	10	0.17	0.50	0.55
3.52	15	0.14	0.53	0.64
5	20	0.13	0.54	0.73
6.66	25	0.13	0.52	0.80
8.56	30	0.12	0.46	0.81
10.76	35	0.12	0.40	0.82
13.33	40	0.11	0.36	0.82

Antiseptics (78).

Substance	Effect on total fermentation
Concentrated solution of glycerol	Slight diminution
Concentrated solution of sugar	Slight increase
Toluene (to saturation or excess)	Less than 10% diminution
Chloroform, 0.5%	Slight increase
Chloroform, 0.8% (saturation)	No change
Chloroform large excess, 17%	64% diminution
Chloral hydrate, 0.7%	Increase up to 27%
Chloral hydrate, 3.5–5.4%	Completely destroyed
Phenol, 0.1%	No change
Phenol, 0.5%	40% diminution
Phenol, 1.2%	Completely destroyed
Thymol, 1%	Slight diminution
Thymol, 5%	Marked diminution
Benzoic acid, 0.1%	7% diminution
Benzoic acid, 0.25%	26% diminution
Salicylic acid, 0.1%	10% diminution
Salicylic acid, 0.27%	35% diminution
Formaldehyde, 0.12%	20% diminution
Formaldehyde, 0.24%	30–60% diminution
Acetone, 6%	20% diminution
Acetone, 14%	80% diminution
Alcohol, 6%	0–2% diminution
Alcohol, 14%	75% diminution
Sodium fluoride, 0.5%	99% diminution
Sodium fluoride, 2.0%	Almost completely destroyed

Antiseptics.—(*Continued*)

Substance	Effect on total fermentation
Ammonium fluoride, 0.55%	Completely destroyed
Sodium azoimide, NaN_3, 0.36%	Slight diminution
Sodium azoimide, NaN_3, 0.71%	Marked diminution
Quinine hydrochloride, 1%	Slight increase
Ozone 10.4–34.8 milligram per 20 cm³	Marked diminution
Hydrocyanic acid, 1.2%	Completely destroyed

Phosphates.—(79).

Sugar, g	Total vol., cm³	Optimum vol. of 0.6 molar phosphate, cm³		Maximum rate, cm³ of CO_2/5 min	
		Glucose	Fructose	Glucose	Fructose
2	35	2	5	7.5	32.2
4	50	1	10	5.4	28.4
1.6	23	2	5	8	17
1	25	1.75	5	5.2	25.9
2	25	5	7.5	16.2	31.2
2	20	2	3.5	7.9	22.6
2	22.5	0.75	2	3.4	22.2

Arsenates.—Fermentation of glucose by yeast juice. C_A = concentration of arsenate, mole/l. R_{max} = maximum rate of fermentation (80); *v. also* (49).

C_A, M/l	R_{max}	C_A, M/l	R_{max}
0	3.5	0.00375	34.9
0.0_4375	6.3	0.0075	29.5
0.0_475	8	0.015	23.2
0.0_315	14.2	0.0375	14.5
0.0_33	19.9	0.075	8.7
0.0_375	29.7	0.1125	5.3
0.0015	35	0.15	3.2

Arsenate concentration	Rate	
	Glucose	Fructose
0.0075 molar	12.1	26.6
0.0225 (opt. for glucose)	13.4	
0.0525 (opt. for fructose)		45.8
0.1125	5.1	39

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PHOTOCHEMICAL KINETICS

Christian Winther

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ABBREVIATIONS AND CONVENTIONS

A Fraction of incident energy absorbed.	A Fraction absorbée de l'énergie incidente.	*A* Der absorbierte Bruchteil der einfallenden Energie.	A Frazione di energia incidente assorbita.
F Light filter (wave filter).	F Filtre de lumière (filtre d'onde).	F Lichtfilter (Strahlenfilter).	F Filtro di luce.
Fs Spark gap.	Fs Distance explosive.	Fs Funkenstrecke.	Fs Distanza esplosiva.
K_c Equilibrium constant. $K_c = [M]^m[N]^n/[A]^a[B]^b$ for $aA + bB \rightleftarrows mM + nN$.	K_c Constante d'équilibre. $K_c = [M]^m[N]^n/[A]^a[B]^b$ pour $aA + bB \rightleftarrows mM + nN$.	K_c Gleichgewichtskonstant. $K_c = [M]^m[N]^n/[A]^a[B]^b$ für $aA + bB \rightleftarrows mM + nN$.	K_c Costante di equilibrio. $K_c = [M]^m[N]^n/[A]^a[B]^b$ per $aA + bB \rightleftarrows mM + nN$.

k_x Velocity constant for reaction of the order x.

$k_{x(z)}$ Velocity constant for x-order reaction in presence of catalyzer or added substance.

p Pressure.

QQ Quartz mercury vapor lamp.

R_λ Range of active wave lengths.

Sp Spectral purification of the monochromatic radiation.

[X] Concentration of the substance X in g-mole/liter.

Z Catalyzer or added substance.

λ Wave length in $\mu\mu$.

α Extinction coefficient.

$$\alpha = \frac{1}{[X]l}\log_{10}\left(\frac{J_o}{J}\right) \text{ where}$$

l = Length of path in cm.

J_o (resp. J) = Intensity of the incident (resp. emergent) radiation.

Bold face numbers following a ± deviation indicate the number of experiments included in the average.

k_x Constante de vitesse pour une réaction du $x^{\text{ième}}$ ordre.

$k_{x(z)}$ Constante de vitesse pour une réaction du $x^{\text{ième}}$ ordre en présence d'un catalyseur ou d'une substance additionnelle.

p Pression.

QQ Lampe de quartz à vapeur de mercure.

R_λ Intervalle des longueurs d'ondes actives.

Sp Purification spectrale d'une radiation monochromatique.

[X] Concentration de la substance X en mol. gr. par litre.

Z Catalyseur ou substance additionnelle.

λ Longueur d'onde en $\mu\mu$.

α Coefficient d'extinction.

$$\alpha = \frac{1}{[X]l}\log_{10}\left(\frac{J_o}{J}\right) \text{ où}$$

l = Épaisseur de la couche absorbante en cm.

J_o (resp. J) = Intensité de la radiation incidente (resp. émergente).

Les chiffres en caractères gras suivant une déviation ± indiquent le nombre des valeurs expérimentales dont on a pris la moyenne.

k_x Reactionsgeschwindigkeitskonstante x-ter Ordnung.

$k_{x(z)}$ Geschwindigkeitskonstante x-ter Ordnung mit Zusatz.

p Druck.

QQ Quartz-QuecksilberDampflampe.

R_λ Wirksame Wellenlänge.

Sp Spektrale Reinigung der monochromatischen Strahlung (Monochromator).

[X] Die Konzentration der Substanz X in g-mol/liter.

Z Ein Katalysator oder Zusatz.

λ Die Wellenlänge in $\mu\mu$.

α Extinktionskoefficient.

$$\alpha = \frac{1}{[X]l}\log_{10}\left(\frac{J_o}{J}\right) \text{ wo}$$

l = Schichtdicke in cm.

J_o (bezw. J) = Intensität der einfallenden (bezw. austretenden) Strahlung.

Schwarze Ziffern nach eine ± Abweichung bedeuten die Anzahl Werte, aus welchen der Mittelwert berechnet wurde.

k_x Costante di velocità per reazioni di ordine x.

$k_{x(z)}$ Costante di velocità per reazioni di ordine x in presenza di catalizzatori o di sostanze aggiunte.

p Pressione.

QQ Lampada di quarzo a vapori di mercurio.

R_λ Lunghezze d'onda attive.

Sp Separazione spettrale di radiazioni monocromatiche.

[X] Concentrazione della sostanza X in grammi molecole per litro.

Z Catalizzatore o sostanze aggiunte.

λ Lunghezza d'onda in $\mu\mu$.

α Coefficiente di estinzione.

$$\alpha = \frac{1}{[X]l}\log_{10}\left(\frac{J_o}{J}\right) \text{ dove}$$

l = Lunghezza del percorso in cm.

J_o (resp. J) = Intensità delle radiazioni incidenti o emergenti.

I numeri scritti in nero dopo uno scarto ± indicano il numero delle esperienze dalle quali è stato calcolato il valore medio.

LIGHT FILTERS FOR THE MERCURY VAPOR LAMP

λ, $\mu\mu$	Composition	Thickness of layer, cm	Transmission		Lit.
			λ	%	
579	0.5 g eosin in 100 cm^3 H$_2$O	0.5	579	9.20	(1)
	"Gelbglas" No. 5657*	0.1	546	0.07	
	"Gelbglas" No. 5899*	0.1	436	0.02	
579	0.25 g eosin in 100 cm^3 H$_2$O	0.5	579	30.3	(1)
	"Gelbglas" No. 5657*	0.1	546	0.27	
	"Gelbglas" No. 5899*	0.1	436	0.14	
579	(*a*) 2 g quinine in 100 cm^3 *N* HCl	1	436	99	(4)
			405	0.3	
	(*b*) 6 g CuSO$_4$.5H$_2$O in 100 cm^3 H$_2$O	1	730	1	
			710	2.2	
			690	4.9	
			670	10.4	
			650	19.4	
			630	35.7	
			610	52.5	
			590	70.4	
	(*c*) 0.02 g tartrazin 0.02 g erythrosin } in 100 cm^3 H$_2$O	1	579	87	
			546	0	
			436	0	
	Total filter		Red	3.2	
546	0.01 g malachite green in 100 cm^3 H$_2$O	0.5	579	3.9	(1)
	"Gelbglas" No. 5657*	0.1	546	22.0	
	"Gelbglas" No. 5899*	0.1	492	33.8	
			436	0.02	
546	(*a*) 2 g quinine in 100 cm^3 *N* HCl	1	436	99	(4)
			405	0.3	
	(*b*) 6 g CuSO$_4$.5H$_2$O in 100 cm^3 H$_2$O	1	730	1	
			710	2.2	
			690	4.9	
			670	10.4	
			650	19.4	
			630	35.7	
			610	52.5	
			590	70.4	
	(*c*) 0.02 g tartrazin in 100 cm^3 H$_2$O	1	436	0	
	(*d*) "Didymglas" (Schott, Jena)	1.3	579	1.3	
			546	84	
	Total filter		Red	3.4	
546	0.42 g "Filtergelb" 0.007 g Saüregrün (Höchst) } in 100 cm^3 H$_2$O	1	546	26	(6)

* Schott, Jena.

LIGHT FILTERS.—(*Continued*)

λ, μμ	Composition	Thickness of layer, cm	Transmission λ	Transmission %	Lit.
492	(*a*) 1.2 g triphenylmethane in 100 cm³ C_2H_5OH	0.55	546 492	0.046 37.4	(³)
	(*b*) 0.1 g "Cyanolechtgrün G" in 100 cm³ H_2O	1.05	436 405	0.0006 0.0008	
436	0.15 g Victoria blue B in 100 cm³ C_2H_5OH	0.5	579 546 492 436 405	0.04 0.11 0.58 29.8 0.1	(¹)
436	0.0075 g rhodamine B 2 g quinine sulfate } In 6 cm³ *N* H_2SO_4 and 94 cm³ H_2O	1	436 405 366 Also red	38 Tr. Tr.	(⁵)
436	(*a*) 2 g quinine in 100 cm³ *N* HCl	1	436 405	99 0.3	(⁴)
	(*b*) 6 g $CuSO_4.5H_2O$ in 100 cm³ H_2O	1	730 710 690 670 650 630 610 590	1 2.2 4.9 10.4 19.4 35.7 52.5 70.4	
	(*c*) 0.003 g acid rhodamine in 100 cm³ H_2O	1	579 546 436	0 0 72	
	(*d*) 0.2 *N* $CuSO_4$ soln. + excess NH_3	1	Absorbs red and fluorescent light		
	Total filter		405 red	*ca.* 0.3 0.7	
405	0.12 g "Diamantfuchsin" 1.2 g triphenylmethane } In 100 cm³ C_2H_5OH	0.5	579 546 405	0.2 0.02 13.5	(¹)
405	0.06 g "Diamantfuchsin" 1.2 g triphenylmethane } In 100 cm³ C_2H_5OH	0.5	579 546 436 405	4.5 0.13 Tr. 36.8	(¹)
405	0.03 g "Diamantfuchsin" 4 g quinine hydrochloride } In 100 cm³ C_2H_5OH(96%)	1	436 405 Also red	Tr. 34	(⁵)
366	0.03 g "Diamantfuchsin" in 100 cm³ H_2O	1	366 Also red	31	(⁵)
313	0.0243 g K_2CrO_4 0.00188 g nitrosodimethylaniline } In 100 cm³ H_2O	1	313 302 436 Also red, yellow and some green	30 19 Tr.	(⁵)

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(For a key to the periodicals see end of volume)

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VELOCITY OF REACTION

$$H_2O_2 \rightarrow H_2O + O$$

(*a*) $[H_2O_2] = 0.05$; Fs; $R_\lambda = 280\text{–}210\mu\mu$; retardation constant, $K = \frac{k_1(z) \times 100}{k_1}$ (⁷)

Z	[Z]	*K*	Z	[Z]	*K*
H_2SO_4	2×10^{-4}	93	NaOH	2×10^{-2}	0
H_2SO_4	4×10^{-3}	66	I_2	2×10^{-6}	60
H_2SO_4	2×10^{-3}	40	$HgCl_2$	4×10^{-4}	33
H_2SO_4	2×10^{-2}	33	KCN	6×10^{-3}	76
H_2SO_4	2×10^{-1}	33	$Na_2S_2O_3$	2×10^{-3}	26
NaOH	2×10^{-4}	60	H_2S	10^{-6}	75
NaOH	2×10^{-3}	20	H_2S	10^{-4}	14

(*b*) $[H_2O_2] = 0.5\text{–}0.01$; Z = H_2SO_4; QQ; $R_\lambda = 305\text{–}316\mu\mu$; titration (⁸)

[Z]	*K*		[Z]	*K*	
0.5×10^{-5}	67 ± 2.3	**4**	0.5×10^{-3}	24 ± 0.7	**22**
0.5×10^{-4}	58 ± 4.9	**4**	0.5×10^{-2}	14 ± 0.6	**12**

(*c*) $[H_2O_2] = 0.6\text{–}1.2$; QQ; unilateral glass filter; 25°C; $KMnO_4$ titration. The *K* values in the presence of the additions (Z) are relative to 100 for pure H_2O_2; λ's in μμ; accuracy ±10% (¹).

Z	10^3[Z]	*K*, for λ up to 200	265	293	305
Nil	0	100	30* ±2.3	16* ±0.0	7† ±0.4
Acetic acid	5	75	100	100	100
Phenylacetic acid	1	13	45	80	100
β-Phenylpropionic acid	*ca.* 3	12	40	70	100
Benzoic acid	5	9			100
Ethyl acetate	5	100	100	100	100
Ethyl benzoate	*ca.* 1	14	50	80	100
Ethyl phenylacetate	*ca.* 1	17	70	85	100
Ethyl cinnamate	*ca.* 0.2	25	45	65	100
Methyl oxalate	5	10	20	35	70
Methyl benzoate	5	9			
Ethylamine	*ca.* 5	5	0	0	0
Aniline	5	7	0	0	0
Benzylamine	5	8	0	0	0
Acetamide	5	65	100	100	100
Benzamide	3	9			
Acetanilide	0.1	60	100	100	100
Ethyl alcohol	5	35	35	35	35
Phenol	2	0	0	0	0
Benzyl alcohol	*ca.* 3.3	8	25	40	40
Acetone	5	70	60	55	50
Acetophenone	0.2	11	40	65	100
Benzophenone	0.1	45	60	100	100
Benzene	5	20		70	
Quinine hydrochloride	0.2	9	20	10	0
Quinine salicylate	0.2	4	0	0	0

* Three experiments. † Four experiments.

(*d*) $[H_2O_2] = 0.6\text{–}1.2$; QQ; unilateral glass filter; titration; accuracy ±10%; retardation independent of λ and temp. (²)

Z_1	$10^3[Z_1]$	Z_2	$[Z_2]$	*K*
$HClO_4$	5	Nil	0	30
Nil	0	$KClO_4$	0.1	100
$HClO_4$	5	$KClO_4$	0.1	40
HNO_3	5	Nil	0	30
Nil	0	KNO_3	0.005	100
Nil	0	$NaNO_3$	0.005	100
Nil	0	$Ba(NO_3)_2$	0.005	110
H_2SO_4	0.5	Nil	0	65
Nil	0	Na_2SO_4	1.0	100
H_2SO_4	0.5	Na_2SO_4	1.0	100
H_2SO_4	5	Nil	0	35
Nil	0	Na_2SO_4	3.0	100
H_2SO_4	5	Na_2SO_4	1.0	75
H_2SO_4	5	Na_2SO_4	2.0	100
Nil	0	K_2SO_4	1.5	100
H_2SO_4	5	K_2SO_4	1.5	100
Nil	0	$MgSO_4$	2.0	100
H_2SO_4	5	$MgSO_4$	2.0	100
H_2SO_4	5	$MgSO_4$	1.0	70
Nil	0	$(NH_4)_2SO_4$	3.0	100
H_3PO_4	5	Nil	0	40
H_3BO_3	5	Nil	0	100
H_3BO_3	100	Nil	0	100

(*d*).—(*Continued*)

Z_1	$10^3[Z_1]$	Z_2	$[Z_2]$	*K*
NaOH	5	Nil	0	0
NaOH	1	Nil	0	2
NaOH	1	Na_2SO_4	1.0	10
NaOH	1	Na_2SO_4	2.0	30
NaOH	1	Na_2SO_4	3.0	70
NaOH	0.5	Nil	0	14
NaOH	0.5	Na_2SO_4	2.0	60
NaOH	0.5	Na_2SO_4	3.0	100
KOH	5	Nil	0	0
KOH	0.5	Nil	0	16
KOH	0.5	K_2SO_4	1.5	70
$Ba(OH)_2$	5	Nil	0	0
NH_4OH	$5NH_3$	Nil	0	10
NH_4OH	$5NH_3$	$(NH_4)_2SO_4$	3.0	60
$C_2H_5NH_3OH$	$5RNH_2$	Nil	0	5
$C_6H_5CH_2NH_3OH$	$5RNH_2$	Nil	0	8

Values of *K* (2)

Z \ $10^3[Z]$	5	2	1	0.5	Z \ $10^3[Z]$	5	2	1	0.5
HCl	20				$MgCl_2$	50	75		100
NaF	120				$BaCl_2$	40			
NH_4Cl	35			100	NH_4Br	55	80		100
NaCl	40	70	80	100	KBr	60	85	100	100
KCl	40	75	80	100	$BaBr_2$	60			

K for halide (Z_1) and sulfate (Z_2) of the same metal; $[Z_1] = 0.005$ (2)

Z_1 \ $[Z_2]$	0	1	1.5	2	3	Z_1 \ $[Z_2]$	0	1	1.5	2	3
NH_4Cl	35			45	55	$MgCl_2$	50			75	
NaCl	40	50		75	100	NH_4Br	55	60			85
KCl	40	60	70			KBr	60	85	100		

NaOCl → NaCl + O

Aqueous solution; Uviol lamp, F; 15 ± 1°C; titration with As_2O_3; *t* in hr (16)

[NaOCl]	[NaCl]	10^3k_1	
0.08	0.0	41.2 ± 0.9	**3**
0.08	0.34	36.7 ± 0.4	**3**

[NaOCl] = 0.075; [NaOH] = 0.0053; $[Na_2CO_3]$ = 0.0089

10^3 [HCl] =	0.0	9.1	17.1	25.3	37.9	49.5
$10^3\ k_1$ =	41.8	51.0	48.7	43.0	30.4	25.0

[NaOCl]	[NaOH]	$10^3\ k_1$	
0.076	0.0	40.8 ± 0.5	**4**
0.076	0.143	40.0 ± 0.9	**4**

[NaOCl]	0.075	0.076	0.013	0.075	0.075	0.013
λ, μμ	436	405	405	366	313	313
10^3k_1	3.69	4.04	3.84	4.75	2.16	13.7
±	0.03	0.04	0.14	0.06	0.03	0.02
	5	**3**	**4**	**4**	**4**	**3**

$2K_3Co(C_2O_4)_3 \rightarrow 2CoC_2O_4 + 3K_2C_2O_4 + 2CO_2$

Aqueous solution; half-watt lamp or QQ, F; analysis by extinction measurement; in white light *ca.* monomolecular, at high dilutions *ca.* bimolecular (concn. in %); *t* in min; velocity/intensity = const. variation of intensity, 1/4.73 (17).

(*a*) With half-watt lamp

$[K_3CoOx_3]$	°C	10^5k_1		k_1 / k_{z_1}*	$[K_3CoOx_3]$ = 0.0001 at 12.0°C	
0.02	12.0	97 ± 0.2	**2**	1.40	$[K_2C_2O_4]$	10^5k_1
0.01	12.0	149 ± 0.8	**4**	1.67	0.0	383
0.005	13.4	249 ± 1.2	**4**	1.69	0.001	316
0.002	14.5	326 ± 2.0	**6**	1.85	0.0025	264
0.001	12.2	383 ± 2.5	**11**	1.81	0.005	232
0.0005	14.7	418 ± 15	**9**	1.88	0.009	225
0.0002	14.3	426 ± 11.5	**15**	1.80	0.035	211
0.0001	13.0	612 ± 37	**6**	1.70	0.080	211
		k_2				
0.0001	13.0	85 ± 4.7	**4**			
0.0001	10.9	95 ± 4.5	**7**			

* k_{z_1} corresponds to an addition of 35–80 moles $K_2C_2O_4$ per mole $K_3Co(C_2O_4)_3$.

(*b*) With QQ

$[K_3CoOx_3]$	°C	10^5k_1	
0.01	10.2	250 ± 6	**6**
0.005	10.4	434 ± 5	**7**
0.002	9.7	666 ± 4	**7**
0.001	11.2	790 ± 22	**4**
0.0002	9.8	799 ± 35	**7**
0.0001	9.5	987 ± 31	**6**

$[K_3CoOx_3] \times 10^3$	Path length, cm	
	1.06	0.52
	10^5k_1	
5	434	521
2	636	776
1	790	734
0.1	987	749

(*c*) With QQ and filter (for filters, *see* p. 160)

λ, μμ	$[K_3CoOx_3]$	°C	10^5k_1		10^2k_2	
436	0.005	10.2	93.9 ± 1.0	**7**	21 ± 0.7	**5**
	0.002	11.3	75.7 ± 1.4	**10**	42.7 ± 0.3	**6**
	0.001	10.9	126 ± 4	**11**	149 ± 2	**9**
	0.0002	10.8	88.3 ± 3.3	**6**	600 ± 50	**9**
405	0.005	11.4	75.2 ± 3.8	**6**	16.4 ± 0.7	**3**
	0.002	10.9	64.5 ± 1.6	**11**	37.1 ± 0.7	**3**
	0.001	8.8	92.1 ± 1.5	**13**	102 ± 1	**5**
	0.0002	10.0	88.3 ± 2.9	**10**	522 ± 14	**9**
366	0.005	10.7	49.7 ± 0.5	**9**	10.9 ± 0.4	**5**
	0.002	10.1	49.7 ± 0.5	**9**	27.7 ± 0.3	**6**
	0.001	11.5	59.5 ± 1.3	**12**	63.8 ± 1.5	**4**
	0.0002	9.4	64.7 ± 1.8	**7**	380 ± 5	**8**

ANTHRACENE → DIANTHRACENE

Arc lamp, glass vessels, *v* in g-mole cm^{-2} sec^{-1} with 1 cm^2 illuminated at 1 cm distance (10)

Solvent	C_6H_6	Toluene	Xylene	Anisole	Phenetole		
°C	80	109	137	154	154	160	167
10^7v	3.42	4.80	4.50	3.10	3.00	3.87	4.42

$C_2H_5OH + O_2$

Catalyzed by ketones; QQ, glass filter; path length 1 mm; 35 ± 0.01°C; measurement of pressure, Δp = cm^3 O_2 required per hr; for complete absorption Δp is independent of [Z] (4).

Z	Benzophenone							
[Z]	1	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{16}$	$\frac{1}{32}$	$\frac{1}{64}$
Δp	10.30	12.00	12.00	11.90	9.00	5.60	5.65	2.28

Z	Phenyl cyclohexyl ketone				Phenyl *n*-hexyl ketone			
[Z]	1	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$	2	1	$\frac{1}{2}$	$\frac{1}{4}$
Δp	5.15	5.00	2.82	1.12	1.00	0.97	0.68	0.22

Z	Acetophenone					Propiophenone			
[Z]	2	$1\frac{1}{2}$	1	$\frac{1}{2}$	$\frac{1}{4}$	2	1	$\frac{1}{2}$	$\frac{1}{4}$
Δp	1.30	1.40	1.42	1.03	0.22	1.10	1.11	0.92	0.20

$C_2H_5OH + O_2$.—(*Continued*)

Z	Phenyl benzyl ketone			Diphenyl-acetophenone		Phenylacetone		
[Z]	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{32}$	$\frac{1}{64}$	3	2	1
Δp	5.05	4.85	2.35	3.13	0.78	0.50	0.48	0.35

Z	Dibenzyl ketone			*asym.*-Diphenyl-acetone		Triphenyl-acetone	*sym.*-Tetra-phenyl-acetone
[Z]	2	1	$\frac{1}{2}$	1	$\frac{1}{2}$	$\frac{1}{8}$	$\frac{1}{50}$
Δp	1.76	1.75	0.85	0.03	0.01	0.05	0.17

Z	Phenyl furfuryl ketone			Diacetyl			
[Z]	2	1	$\frac{1}{2}$	4	3	2	$1\frac{1}{2}$
Δp	0.07	0.10	0.10	16.00	15.30	15.30	15.10

Z	Diacetyl						
[Z]	1	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{16}$	
Δp	14.90	14.10	10.60	6.40	2.60	0.64	0.16

Z	Benzil			Acetylbenzene			
[Z]	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{16}$	4	$3\frac{1}{2}$	3	2
Δp	3.20	1.44	0.52	8.60	11.70	12.90	12.60

Z	Acetylbenzene						
[Z]	$1\frac{1}{2}$	1	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{16}$
Δp	12.80	13.10	10.80	8.50	6.05	4.15	2.08

Z	Furil	Benzofuril				Terephthalo-phenone			Isophthalo-phenone	
[Z]	$\frac{1}{16}$	2	1	$\frac{1}{2}$	$\frac{1}{16}$	0.01	0.006	0.004	0.1	0.01
Δp	2.80	5.80	6.30	6.20	2.20	2.80	3.55	3.45	2.80	1.48

Z	Phenanthrene-quinone		Anthra-quinone	α-Hydrindone			1, 2-In-dandione	
[Z]	0.02	0.01	0.004	2	1	$\frac{1}{2}$	$\frac{1}{8}$	$\frac{1}{16}$
Δp	10.50	6.25	0.67	0.19	0.17	0.07	0.92	0.39

The following are inactive: Dicyclohexyl ketone, Di-*n*-hexyl ketone, Triphenylacetophenone, Acetone, Fluorenone, Pentane triketone, Diphenyl triketone, Alloxan.

$CHI_3 + O_2$

(*a*) Uviol lamp; quinine filter; active λ = 436; stirred with O_2, 22°C; $k = [I_2]/2t$; t in min (12); k_L = direct reaction in light; k_N = after effect in dark.

	In benzene							
$[CHI_3]$	0.10	0.08	0.06	0.04	0.02	0.02	0.01	0.005
10^6k_L	91.5	85.6	73.3	58.1	38.6	30.9	25.3	15.5
10^6k_N	50.5	37.9	26.7	15.7	6.4	6.2		
	In C_2H_5OH ($k_N = 0$)							
10^6k_L		4.56	4.25	4.00	3.12		1.75	0.84

Solvent	10^6k_L	10^6k_N
CCl_4	39.4	2.4
C_6H_6	34.6	5.5
CS_2	24.1	0
$CH_3CO_2C_2H_5$	8.1	0.9
C_2H_5OH	2.3	0
95% C_2H_5OH + 5% H_2O	1.29	0
85.5% C_2H_5OH + 14.5% H_2O	0.61	0
80% C_2H_5OH + 20% H_2O	0.44	0
Acetone	0.7	0

(*b*) Uviol, F; active λ = 436; 19°C; benzene solution; effects of catalyzers (13)

Z	[Z]	10^6k_L	10^6k_N
Nil	0	36.9	6.1
NO_2	66×10^{-7}	34.1	6.9
$NaNO_2$	Satd.	44	0
KNO_3	Satd.	34.6	6.4
$K_2Cr_2O_7$	Satd.	32.2	5.8
Na formate	Satd.	36.6	6.4
Cu acetate	Satd.	38.0	5.0
Na butyrate	Satd.	31.5	6.5

Z	Z per 100 cm³	10^6k_L	10^6k_N
$CHCl_3$	5 cm³	38.1	7.9
$C_6H_5NO_2$	0.1 cm³	35.6	7.4
Cinnamic acid	0.025 g	34.6	6.4
$C_6H_5NH_2$	5 cm³	4.5	0
Nitrosodimethylaniline	0.0_3125 g	33.0	7.0
Anethole	0.25 cm³	27	0
Aminoazobenzene	0.0_35 g	33.1	5.8
Triphenylmethane	0.0025 g	32.5	9.5
Crystal red	0.0025 g	39.6	2.4
Cyanin	0.0_325 g	36.2	5.8

Dyes + O_2

In collodion; Nernst lamp, Sp; analysis by extinction measurement; $\Delta[\text{Dye}]/[\text{Dye}] \times t = a + bp_{O_2}$; p_{O_2} = pressure of O_2 in cm Hg; (9); $A_o = A$ at beginning; t_s = time of exposure, min.

Dye	λ	A_o	t_s	a	b
Cyanin	589	0.71	5	0.0031	0.0_331
Pinachrome	580	0.62	5	0.0024	0.0_329
"Lepidincyanin"	604	0.18	7	0.020	0.0_345

HYDROLYSIS OF ACETONE, ETHYL ALCOHOL AND ACETALDEHYDE

Fs, unilateral filter; aqueous solutions; conductivity measurement; Sen. = Δ[X] per unit of incident radiation (E) (6)

λ	E	Acetone		Ethyl alcohol		Acetaldehyde	
		α	Sen.	α	Sen.	α	Sen.
360–320	324	<1	0.1		0.7	2.8	1.3
298–288	81	10	21		10	5.3	79
274.8	113						
257.2	84	12	20.8	<0.54	12	3.2	4.2
246.9	28						
231.3	753	3	0.6	7	35	1.2	1.7
228.8	199						
226.5	199						
226.5	199	0.8	0.5	27	116	9	3.8
219.5	339						
214.4	256						

$CH_2ClCOOH + H_2O \rightarrow CH_2OHCOOH + HCl$

QQ, 27°C; analysis as AgCl (resp. AgBr), resp. acid titration (5)

[Acid]		$CH_2ClCOOH$	$CH_2BrCOOH$
1.0	10^6k_1 =	10	28
2.0	10^6k_1 =	5	16.5

HALOGEN ACIDS + C_2H_5OH

Aqueous solution; arc lamp; [acid] = 0.5; 18°C, *t* in min; analysis, as AgCl (resp. AgBr), resp. titration with $NaHSO_4 + KI_3$ (3)

Vol. % C_2H_5OH	10^6k_1			
	Cl-acetic	Br-acetic	Cl-succinic	Br-succinic
0	40.3	27	63.6	84.6
25	56.0	485		
50	70.0	947	155.0	258.0
75	70.0	662		
100	71.0	479		

HALOGEN ACIDS + EXCESS KOH

Aqueous solution; QQ, quartz vessels; *t* in hr; Z = 5 drops 5% soln. of $CuSO_4$ per 50 cm³; A = *p*-bromobenzenesulfonic, B = *p*-bromobenzoic, C = *p*-chlorobenzoic (15).

Acid	°C	In dark + Z		In light		In light + Z	
		10^3k_1		10^3k_1		10^3k_1	
A	107	3.71 ± 0.28	**4**	36.9 ± 0.2	**3**	70.3 ± 3.3	**4**
B	103–105	1.46 ± 0.24	**2**	78.8 ± 2.7	**3**	101.3 ± 31	**3**
C	104–105	0		17.86 ± 0.18	**4**	18.21 ± 0.28	**4**

$C_2H_5OH + (NH_4)_2CrO_4$ (RESP. $(NH_4)_2Cr_2O_7$)

Aqueous solution; Uviol lamp, F for λ = 436; 20°C; titration; $k = \Delta[\text{chromate}] \times 10^3/t(\text{hr})$ (14)

$[(NH_4)_2Cr_2O_7] = (8.3\text{–}8.7) \times 10^{-3}$		$[C_2H_5OH] = 64\%$	
$[C_2H_5OH]$	10^2k	$[(NH_4)_2Cr_2O_7]$	10^2k
87%	36	161.5×10^{-3}	40
64%	23	25.1×10^{-3}	35
48%	16	16.1×10^{-3}	30
32%	9.5	8.45×10^{-3}	21
8.1%	4.8		

$[(NH_4)_2CrO_4] = (8.4\text{–}8.7) \times 10^{-3}$		$[C_2H_5OH] = 64\%$	
$[C_2H_5OH]$	10^2k	$[(NH_4)_2CrO_4]$	10^2k
87%	39	84.58	53
80%	34	48.01	44
64%	24	25.22	29
32%	3.35	17.02	25
8.1%	3.1	4.42	9.6

$H_2 + S \rightarrow H_2S$

QQ, active λ = 280–270 μμ; $\Delta[H_2S]$ in g/sec × 10^8; *p* = partial pressure of sulfur vapor (11)

p = 6.3 mm Hg		320°C		
°C	$\Delta[H_2S]$	*p*, mm	$\Delta[H_2S]$	$\Delta[H_2S]/p$
300	8.99	5.25	11.6	2.22
310	13.37	6.30	16.4	2.60
320	17.45	7.60	17.4	2.29
330	24.83	9.10	20.7	2.27
340	34.39			

LITERATURE

(For a key to the periodicals see end of volume)

(1) Anderson and Taylor, *1*, **45**: 650; 23. (2) Anderson and Taylor, *1*, **45**: 1210; 23. (3) Cassel, *7*, **92**: 113; 16. (4) Cohen, *64P*, **26**: 443; 23. (5) Euler and Cassel, *7*, **84**: 371; 13. (6) Henri and Wurmser, *34*, **156**: 230; 13. *51*, **3**: 305; 13. (7) Henri and Wurmser, *34*, **157**: 284; 13. (8) Kornfeld, *99*, **21**: 66; 21. (9) Lasareff, *7*, **78**: 657; 12.

(10) Luther and Weigert, *7*, **53**: 385; 05. (11) Norrish and Rideal, *4*, **125**: 2070; 24. (12) Plotnikow, *7*, **75**: 337, 385; 11. (13) Plotnikow, *7*, **76**: 743; 11. (14) Plotnikow, *99*, **19**: 40; 19. (15) Rosenmund, Luxat and Tiedemann, *25*, **56**: 1950; 23. (16) Spencer, *4*, **105**: 2565; 14. (17) Vránek, *9*, **23**: 336; 17.

TEMPERATURE COEFFICIENTS

Except in the case of the reaction, $NH_3 \rightarrow N + 3H$, all known temperature coefficients refer only to the incident (not the absorbed) light. Possible changes in absorption with temperature are therefore not taken into account.

A = arc lamp; B = blue; D = in dark; Da = daylight: DB = dark blue; G = green; Gl = incandescent lamp; Mf = metal filament; Or = orange; R = red; S = sunlight; T = tungsten arc lamp; UV = ultraviolet; V = violet; W = white.

Substance (process)	Radiation	θ_1, θ_2, °C	$k_{\theta+10}/k_\theta$	Lit.
	Gases			
$H_2 + O \rightarrow H_2O$	UV > 220	150–240	1.04	(18)
		131–191	1.12	(3)
		130–194	1.11	(3)
		191–228	1.06	(3)
$H_2O \rightarrow H_2 + O$	UV > 220	8–20	1.137	(56)
$H_2 + S^*$ (QQ)	280–270	300–340	1.37	(40)
	D	300–340	1.48	(40)
$2O_3 \rightarrow 3O_2(+Cl_2)$	W-Mf	16–25.2	1.17	(59)
$H_2 + Cl_2 \rightarrow 2HCl$	W-Mf	10–20	1.14	(9)
		20–30	1.17	(9)
		30–40	1.23	(9)
		40–50	1.25	(9)
		50–60	1.23	(9)
		10–20	1.27	(42)
		20–30	1.15	(42)
		30–40	1.45	(42)
	G 550–530	10–20	1.50	(42)
		20–30	1.50	(42)
		30–40	1.56	(42)
	B 490–470	10–20	1.29	(42)
		20–30	1.34	(42)
		30–40	1.31	(42)
	V 460–440	10–20	1.22	(42)
		20–30	1.21	(42)
		30–40	1.20	(42)
	UV 400–350	10–20	1.19	(42)
		20–30	1.15	(42)
		30–40	1.17	(42)
$H_2 + Cl_2 \rightarrow 2HCl(+I_2)$	W	0–20	1.091	(41)
		20–40	1.028	(41)
	G	0–10	1.133	(41)
		10–20	1.147	(41)
		20–30	1.250	(41)
		30–40	1.240	(41)
	B	0–20	1.107	(41)
		20–30	0.939	(41)
		30–40	0,882	(41)
	V	0–20	1.084	(41)
		20–30	0.919	(41)
		30–40	0.868	(41)
$H_2 + Br_2$	W-T	160–218	1.58 ± 0.13	(11)
	D	224.7–301.3	2.09 ± 0.08	(10)
$HI \rightarrow H + I$	UV	150–175	1.00	(12)
$Cl_2O \rightarrow Cl_2 + O$	V	10–40	1.09	(13)
$SO_2 + O \rightarrow SO_3$	UV > 220	50–160	1.2	(17)
$SO_2 + Cl_2 \rightarrow SO_2Cl_2$	UV > 220	18–99	0.88	(57)
$NH_3 \rightarrow N + 3H$	214–202.5	10–20	1.00	(32)
		20–100	1.05	(33)
		100–200	1.04	(33)
		200–300	1.05	(33)
		300–400	1.06	(33)
		400–500	1.04	(33)
$NOCl \rightarrow NO + Cl$	W	0.1–78	1.0	(30)
	Aqueous solutions			
$H_2O_2 \rightarrow H_2O + O$	UV		1.43	(2)
	UV > 220	10–30	1.15	(56)
		21–35.5	1.45	(38)
		35–45	1.54	(38)
	UV > 254	21.4–34.3	1.32	(31)
$Cl_2 + H_2O \rightarrow HClO + HCl$	UV > 220	15–30	1.40 ± 0.02	(6)
$NaOCl \rightarrow NaCl + O$	UV > 254	10–24	1.06 ± 0.01	(55)
$NaNO_2 + I_2$	W-S	25–35	1.1	(4)†
	D	40–60	2.8	(4)†

Aqueous solutions.—(*Continued*)

Substance (process)	Radiation	θ_1, θ_2, °C	$k_{\theta+10}/k_\theta$	Lit.
$Fe^{+++} + I^- \rightarrow Fe^{++} + I$ (displacement of equilibrium)	579	25–35	1.17	(53)
$Fe^{+++} + I^- \rightarrow Fe^{++} + I$	D	25–35	2.71	(53)
$CCl_3CO_2H + H_2O$	W-S	75–85	1.92	(4)†
	D	80–90	4.28	(4)†
Lactic acid + $H_2O \rightarrow CO_2 + C_2H_5OH$	UV	30–75	1.04	(24)
$C_2H_5OH + (NH_4)_2CrO_4$	436	20–30	1.02 ± 0.02	(51)
$C_2H_5OH + (NH_4)_2Cr_2O_7$	436	20–30	0.99 ± 0.05	(51)
Na formate + I_2	W-S	30–40	*ca.* 2.6	(22)
	D	25–35	4.01	(20)
		25–50	3.89	(20)
Na formate + $HgCl_2$	W-S	30–40	*ca.* 2.3	(22)
	D	25–40	4.03	(20)
		40–50	3.63	(20)
$C_2H_2O_4 + CrO_3 + MnSO_4$	W-S	10–20	*ca.* 1.3	(22)
	D	0–20	2.98	(20)
$C_2H_2O_4 + KMnO_4 + MnSO_4$	W-S	10–20	*ca.* 1.1	(22)
	D	0–20	3.21	(52)
$C_2H_2O_4 + FeCl_3$	W-S	3–44	1.02 ± 0.02	(35)
		21–61	1.01	(7)
	D	40–62.1	5.26	(34)
$(NH_4)_2C_2O_4 + HgCl_2$	W-S	0– 8	1.07	(23)
		8–15	1.08	(23)
		15–25	1.12	(23)
		25–30	1.24	(23)
		30–40	1.27	(23)
		40–48	1.23	(23)
		48–60	1.37	(23)
		60–80	1.29	(23)
		80–100	1.91	(23)
	W-A	20–30	1.28 ± 0.05	(44)
		30–40	1.33 ± 0.07	(44)
	B 478–410	20–40	1.22 ± 0.05	(44)
	UV 400–280	20–40	1.13 ± 0.06	(44)
$(NH_4)_2C_2O_4 + HgCl_2$ (+eosin)	W-A	20–30	1.65 ± 0.07	(44)
		30–40	1.29 ± 0.11	(44)
	G 540–505	20–40	1.77 ± 0.03	(44)
$K_2C_2O_4 + HgCl_2$	D	79.6–99.6	2.24	(21)
$K_2C_2O_4 + I_2$	R	25–40	3.10	(8)
	B	25–40	3.04	(8)
	D	25–40	7.2	(8)
		40–50	6.1	(20)
		50–60	5.4	(20)
$K_2C_2O_4 + Br_2$	W-Gl	0–15	1.98	(8)
	D	0–11.5	5.99	(8)
$C_2H_2O_4 + HIO_3$	W-S	33–43	2.4	(4)†
	D	29–59	3.19	(4)†
		59–69	2.98	(4)†
K cobaltioxalate	W	11.9–21.9	1.06	(58)
	D	60.1–67.2	4.6	(58)
$C_2H_2O_4$ + uranyl salt	W-S	4–40	1.0	(15)
$C_2H_2O_4$ + uranyl sulfate	UV	25–35	1.07	(1)
		35–45	1.05	(1)
Tartaric acid + Br_2	B	24.3–34.3	1.7–2.0	(25)
Mandelic acid + $TiCl_4$	Da	10–27	2.2	(5)
Quinine + CrO_3	UV > 254	23–65	1.04	(28)
	D	25–60	1.88	(21)
Levulose	UV > 220	40–70	1.035	(7)
Cane sugar + H_2O	W-S	30–40	1.79–1.18	(4)†
	D	30–40	3.82	(4)†
Tetanus toxin	UV > 220	0–24	*ca.* 1.0	(16)

Other solutions

Substance (process)	Radiation	θ_1, θ_2, °C	$k_{\theta+10}/k_\theta$	Lit.
$CHI_3 + O_2$:				
(In C_6H_6)	UV > 254	6–51.3	1.42 ± 0.06	(49)
(In C_2H_5OH)	UV > 254	20.5–40.1	1.415 ± 0.015	(49)
Cinnamic acid + Cl_2 (in CCl_4)	UV > 254	8–31	1.402 ± 0.002	(39)
Cinnamic acid + Br_2 (in CCl_4)	UV > 254	1.5–19	1.42 ± 0.01	(50)
	W	32–42	2.0	(26)
Cinnamic acid + Br_2 (in C_6H_6)	UV > 254	6–19	1.37 ± 0.01	(50)
$C_6H_6 + Br_2$	UV > 254	6–19	1.40 ± 0.01	(50)

Other solutions.—(*Continued*)

Substance (process)	Radiation	θ_1, θ_2, °C	$k_{\theta+10}/k_\theta$	Lit.
Toluene + Br_2	UV > 254	1–14	1.9	(14)
		18–33	1.8	(14)
		1–33	2.0	(14)
	D	0–10	4.8	(14)
		10–25	5.6	(14)
		25–33	3.9	(14)
Stilbene + Br_2 (in CCl_4)		23–33	2.6	(26)
		33–43	2.5	(26)
Allocinnamylideneacetic acid + I_2 (in CCl_4)	W	24–34	1.75	(27)
Benzophenone + C_2H_5OH	W-S	26.5–76.5	1.063 ± 0.003	(19)
o-Chlorobenzophenone + C_2H_5OH	W-S	26.5–76.5	1.101 ± 0.007	(19)
Anthracene → Dianthracene (in phenetole)	UV-A	154–167	1.47	(37)
β-Methylanthracene (in C_6H_6)	UV > 220	70–80	1.10	(60)
β-Methylanthracene (in toluene)	UV > 220	80–105	1.025 ± 0.025	(60)
Di-β-methyldianthracene (in phenetole)	D	150–160	2.74	(60)
		160–170	2.60	(60)
Styrene→Metastyrene (liquid)	W-S	3–35	1.34	(36)

* Partial pressure of sulfur vapor = 6.3 mm.

† These values have been calculated from the velocity constant for the combined dark and light reaction and for the reaction in the dark.

FADING OF DYES

Substance (process)	Radiation	θ_1, θ_2, °C	$k_{\theta+10}/k_\theta$	Lit.
Cyanin (in collodion)	600	19.0–91.2	1.036 ± 0.004	(54)
	560	19.5–88.7	1.084 ± 0.0002	
Pinachrome (in collodion)	600	16.6–58.0	1.067 ± 0.0002	
	580	18.3–79.2	1.079 ± 0.0005	
Pinaverdol (in collodion)	570	18.2–69.5	1.069 ± 0.0001	
Pinacyanol (in collodion)	610	19.1–62.8	1.038 ± 0.0001	
New methylene blue (in glycerol)	Or	19– 81	1.6	(48)
Fluorescent blue (in glycerol)	Or	19– 81	1.6	
Uranin (in glycerol)	Or	19– 81	1.00	
Eosin (in glycerol)	Or	15–105	1.00	
Visual purple (solution)	W-Gl	7– 36	1.0 *	(29)

PHOTOTROPIC TRANSFORMATION (SOLIDS)

Substance (process)	Radiation	θ_1, θ_2, °C	$k_{\theta+10}/k_\theta$	Lit.
Triphenylfulgide (coloration)	G	25– 35	1.65	(47)
		35– 45	1.68	
	DB	18– 28	1.32	
		28– 38	1.31	
		38– 48	1.40	
Triphenylfulgide (decoloration)	718–639	23– 33	1.08	(47)
	614–574	28– 38	0.92	
		38– 48	0.87	
Benzaldehydephenylhydrazone (coloration)	DB	20– 30	1.08	(47)
		30– 40	1.16	
	V	14– 20	1.02	
		20– 40	1.05	
		40– 50	1.06	
	W-S	−80– 0	1.067	(43)
Benzaldehydephenylhydrazone (decoloration)	D	60– 70	1.7	(43)
		80– 90	1.71	(45)
		90–100	1.69	
		100–110	1.72	

Phototropic Transformation.—(*Continued*)

Substance (process)	Radiation	θ_1, θ_2, °C	$k_{\theta+10}/k_\theta$	Lit.
Benzyl-*o*-tolylosazone (coloration)	W-S	15– 25	1.05	(47)
		25– 35	1.04	
		35– 45	1.07	
	DB	15– 25	1.11	
		25– 35	1.13	
		35– 45	1.13	
Piperyl-*o*-tolylosazone (coloration)	W-S	−90–−10	1.06 ± 0.01	(45)
Piperyl-*o*-tolylosazone (decoloration)	D	−10–+10	2	(45)
Salicylidene-β-naphthylamine (coloration)	W-S	0– 10	1.43 ± 0.04	(43)
	G	40– 50	1.80	(46)
		50– 60	1.80	
		60– 70	1.75	
	B	40– 60	1.45	
	V	50– 60	1.39	
Salicylidene-β-naphthylamine (decoloration)	D	90–110	2.0	(43)
Na diacetyl-di-*p*-diaminostilbene-di-*o*-disulfonate (coloration)	W-S	−10–+20	1.07	(46)
Na diacetyl-di-*p*-diaminostilbene-di-*o*-disulfonate (decoloration)	D	−10–+20	*ca.* 1.65	(46)

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(For a key to the periodicals see end of volume)

(1) Anderson and Robinson, *1*, **47**: 718; 25. (2) Anderson and Taylor, *1*, **45**: 1210; 23. (3) Andrejeff, *53*, **43**: 1342; 11. *9*, **19**: 551; 13. (4) Banerji and Dhar, *93*, **134**: 172; 24. (5) Benrath and Obladen, *99*, **22**: 65; 22. (6) Benrath and Tuchel, *99*, **13**: 383; 14. **14**: 238; 15. *cf.* Dawson, *99*, **14**: 213; 15. (7) Berthelot, *34*, **160**: 441; 15. (8) Berthoud and Bellenot, *37*, **7**: 307; 24. *42*, **21**: 308; 24. (9) Bevan, *201*, **12**: 398; 04.

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(20) Dhar, *4*, **111**: 707; 17. (21) Dhar, *14*, **11**: 130; 19. (22) Dhar, *4*, **123**: 1856; 23. (23) Eder, *75*, **80**: 636; 79. (24) Euler and Ryd, *205*, **51**: 97; 13. (25) Ghosh and Mukherjee, *482*, **2**: 165; 25. (26) Ghosh and Purkayestha, *482*, **2**: 261; 25. (27) Ghosh and Gupta, *482*, **2**: 241; 25. (28) Goldberg, *99*, **4**: 61; 06. (29) Hecht, *223*, **3**: 285; 20.

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(40) Norrish and Rideal, *4*, **125**: 2070; 24. (41) Padoa, *36*, **51 I**: 193; 21. (42) Padoa and Butironi, *22*, **25 II**: 215; 16. *36*, **47**: 6; 17. (43) Padoa and Minganti, *22*, **22 II**: 500; 13. *36*, **45 I**: 15; 15. (44) Padoa and Minganti, *22*, **24 II**: 97; 15. (45) Padoa and Tabellini, *22*, **21 II**: 188; 12. *36*, **45 I**: 10; 15. (46) Padoa and Zazzaroni, *22*, **24 I**: 828; 15. (47) Padoa and Zazzaroni, *22*, **25 I**: 808; 16. (48) Perrin, *34*, **177**: 665; 23. (49) Plotnikow, *7*, **75**: 337, 385; 11.

(50) Plotnikow, *7*, **78**: 573; 12. (51) Plotnikow, *99*, **19**: 40; 19. (52) Purkayestha and Dhar, *93*, **121**: 1561; 22. (53) Rideal and Williams, *4*, **127**: 258; 25. (54) Schwezow, *99*, **9**: 65; 10. (55) Spencer, *4*, **105**: 2565; 14. (56) Tian, *16*, **5**: 248; 16. (57) Trautz, *9*, **21**: 329; 15. (58) Vránek, *9*, **23**: 336; 17. (59) Weigert, *9*, **14**: 591; 08.

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DISPLACEMENT OF EQUILIBRIUM

$3O_2 \rightarrow 2O_3$

Al-Fs; pressure measurement (5)

°C	20	40	54
Equilibrium at, % O_3	3.4	3.15	2.7

$H_2O \rightarrow H_2 + O$

QQ, active: ultra-violet >220; gas at rest; gasometric measurement (1)

°C	150	150	150	150	240
Initial p, atm	0.825	0.585	0.448	0.370	0.825
% decomposition	0.1237	0.1992	0.2960	0.3618	0.1240
$10^{11} K_c$	2.23	6.65	16.8	28.3	1.84

Formation and Decomposition of Halogen Acids

QQ, gas at rest; iodomet. and acidimet. titration (3)

Process	λ	Initial p, atm.	°C	K_c
$HI \rightarrow H + I$	>220	0.97–0.985	13.2–14.0	35.8
$H + I \rightarrow HI$	>220	0.4		23.10
	>220	0.66		33.45
	>220	1		54.26
	>220	1.33		60.30
	>254	0.985	13.2	∞
	>300	0.99	12.2	∞
$HBr \rightarrow H + Br$	>220	0.99-1	12-19	∞
	>254	1	*ca.* 18	*ca.* 0.2
	>300	1	*ca.* 18	0
$HCl \rightarrow H + Cl$	>220	1		5.4×10^{-6}
	>254	1		0
	>300	1		0

$CO_2 \rightarrow CO + O$

QQ, λ = 254–220; gas at rest; 240°C; $\alpha = 33.31–0.0194\ p_{CO_2}$ (2)

p_{CO_2}, mm	1397	818	325	94.7
α = % decomposition	6.06	17.06	27.39	31.60
$10^5 K_c$	0.54	8.50	17.43	8.62

Fumaric Acid (F) ⇄ Maleic Acid (M)

(*a*) Fs; stirring; conductivity measurement; values computed from velocity measurements (6)

[F + M] / λ	0.0102	0.00306
	% M at equilibrium	
207	76.4	68.3
253	69.6	63.5
282	80.6	76.0
	75.5	69.3

(*b*) QQ, glass or quartz vessels; 45–50°C (4)

[F + M]	0.02	0.04	0.05	0.2
% M at equilibrium	72.1	74.2	74.7	79

LITERATURE

(For a key to the periodicals see end of volume)

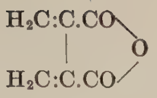
(1) Coehn and Grote, *Nernst Festschrift*, 136; 13. *See also* Grote, *Diss.*, Göttingen, 1912. *cf.* Weigert, *25*, **46**: 815; 13. (2) Coehn and Sieper, *7*, **91**: 347; 16. (3) Coehn and Stuckardt, *188*, **1916**: 99. (4) Kailan, *7*, **87**: 333; 14. (5) Regener, *8*, **20**: 1033; 06. (6) Warburg, *76*, **1919**: 960.

PHOTOTROPY

A comprehensive review with a list of substances studied is given in (34).

The following classes of compounds show phototropy (in absence of light designated by (D); on exposure to light by (L)):

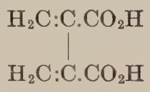
Fulgides (32, 33, 36)



Diaryl derivatives: yellow to orange (D); orange to dark brown (L).

Triaryl derivatives: orange to red (D); dark brown (L).

Fulgenic acids, their salts and esters (36):



$$\begin{array}{l} H_2C{:}C.CO_2H \\ \quad | \\ H_2C{:}C.CO_2H \end{array}$$

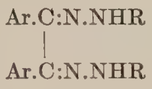
White to pale yellow (D); yellowish green, yellow or orange (L).

Hydrazones (7, 8, 13, 15, 16, 17, 18, 21, 24, 36)

Ar.HC:N.NHR

White to yellowish white (D); rose to purple-red (L).

Osazones (1, 14, 19, 20)



$$\begin{array}{l} Ar.C{:}N.NHR \\ \quad | \\ Ar.C{:}N.NHR \end{array}$$

Stilbene derivatives (35).

For other organic compounds showing phototropy, *see* (3, 5, 9, 10, 11, 22, 25, 26, 27, 28, 29, 30, 34, 37, 38).

INORGANIC COMPOUNDS

	(D)	(L)	Lit.
Lithopone	white	gray	(2, 23)
CaS, SrS	white	rose to violet	(12)
Li_2NH	white	red	(4)
SnI_2	red	yellow	(6)

SOLUTIONS IN $CHCl_3$ (31)

	(D)	(L)
α-Naphthylaminocamphor	colorless	green
m-Phenylenebisaminocamphor	colorless	green
ar-Tetrahydro-*α*-naphthylaminocamphor	pale red	green

LITERATURE

(For a key to the periodicals see end of volume)

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(10) Heilbron, Hudson and Huish, *4*, **123**: 2273; 23. (11) ter Meer, *13*, **181**: 1; 76. (12) Mourelo, *149*, **25**: 15; 08. *132*, **10 I**: 231; 12. *34*, **158**: 122; 14. **160**: 174; 15. **161**: 172; 15. (13) Padoa, *22*, **18 I**: 694; 09. (14) Padoa and Bovini, *22*, **20 II**: 712; 11. (15) Padoa and Graziani, *22*, **18 II**: 269; 09. (16) Padoa and Graziani, *22*, **18 II**: 559; 09. (17) Padoa and Graziani, *22*, **19 I**: 489; 10. (18) Padoa and Graziani, *22*, **19 II**: 193; 10. (19) Padoa and Santi, *22*, **19 II**: 302;10.

(20) Padoa and Santi, *22*, **20 I**: 675; 11. (21) Padoa and Santi, *22*, **20 II**: 196; 11. (22) Peuckert and Siegel, *quoted by* Stobbe, *221*, **74**: 161; 22. (23) Phipson, *34*, **93**: 387; 81. *135*, **44**: 138; 81. **45**: 61; 82. (24) Santi, *22*, **20 II**: 228; 11. (25) Schönburg, *Diss.*, Leipzig, 1913, p. 103. (26) Senier and Clarke, *4*, **105**: 1917; 14. (27) Senier and Forster, *4*, **105**: 2462; 14. (28) Senier and Shepheard, *4*, **95**: 441; 09. (29) Senier and Shepheard, *4*, **95**: 1943; 09.

(30) Seiner, Shepheard and Clarke, *4*, **101**: 1950; 12. (31) Singh, *1*, **43**: 333; 21. *482*, **1**: 45; 24. (32) Stobbe, *13*, **359**: 1; 08. (33) Stobbe, *13*, **380**: 1; 11. (34) Stobbe, *221*, **74**: 161; 22. (35) Stobbe and Mallison, *25*, **46**: 1226; 13. (36) Thormann, *Diss.*, Leipzig, 1912. (37) von Walther, *52*, **67**: 445; 03. (38) Wilson, Heilbron and Sutherland, *4*, **105**: 2892; 14.

QUANTUM SENSITIVITY

Additional Abbreviations

B	Bolometer.	B	Bolomètre.
E_A	Energy absorbed, erg cm^{-2} sec^{-1}.	E_A	Énergie absorbée, erg cm^{-2} sec^{-1}.
E_T	Total energy absorbed by the system, erg sec^{-1}.	E_T	Énergie totale absorbée par le système, erg sec^{-1}.
Gl	Incandescent lamp.	Gl	Lampe à incandescence.
Sk	Radiation calorimeter.	Sk	Calorimètre à radiation.
Ts	Thermopile.	Ts	Pile thermoélectrique.
n	Quantum sensitivity.	n	Sensibilité au quantum.
$n = \Delta[X]N\,\mathbf{h}\gamma/E_A$, where N = Avogadro's number, **h** = Planck's constant, γ = frequency.		$n = \Delta[X]N\,\mathbf{h}\gamma/E_A$, où N = nombre d'Avogadro, **h** = constante de Planck, γ = fréquence.	

B	Bolometer.	B	Bolometro.
E_A	Die absorbierte Energie, erg cm^{-2} sec^{-1}.	E_A	Energia assorbita, erg cm^{-2} sec^{-1}.
E_T	Totale Energie bei dem System absorbiert, erg sec^{-1}.	E_T	Energia totale assorbita dal sistema, erg sec^{-1}.
Gl	Glühlampe.	Gl	Lampada a incandescenza.
Sk	Strahlungskalorimeter.	Sk	Radiocalorimetro.
Ts	Thermosäule.	Ts	Termopila.
n	Quantenempfindlichkeit.	n	Sensibilità per un quanto.
$n = \Delta[X]N\,\mathbf{h}\gamma/E_A$ wo N = die Avogadrosche Zahl, **h** = die Plancksche Konstante, γ = die Frequenz.		$n = \Delta[X]N\,\mathbf{h}\gamma/E_A$, dove N = numero di Avogadro, **h** = costante di Planck, γ = frequenza.	

GAS REACTIONS

$3O_2 \rightarrow 2O_3$

p, kg/cm²	λ	$10^{-2}E_T$	A	n	N*	Remarks	Lit.
95–150	203–214	47–182	0.95–0.99	1.67		Fs, Sp, B	(47)
98–131	209	85–174	0.95–0.98	1.87± 0.03	12	Fs, Sp, B. Bomb O_2	(49)
115–135	209	86–117	0.933–0.956	1.74± 0.05	6		
300	209	98–115	0.978	1.52± 0.02	4		
110–143	253	90–127	0.437–0.589	1.09± 0.07	6		
124–139	253	85–103	0.378–0.457	1.09± 0.04	3		
300	253	157–196	0.88	0.57± 0.04	4		
136–146	209		0.88–0.98	1.85± 0.04	3	Fs, Sp, B. 33–95 vol. % O_2, 67–5 vol. % N_2,	(50)
293.5	209		0.94	1.30		21 vol. % O_2, 79 vol. % N_2	
47.5	207	64–111	0.636	1.06± 0.03	7	Fs, Sp, B. Streaming gas	(54)
47.5	207	68–92	0.636	1.00± 0.01	8		
47.5	207	76–102	0.636	1.06± 0.02	8		
97	253	85–101	0.317	0.56± 0.02	3		
97	253	86–116	0.311	0.59± 0.02	4		
97	253	92–185	0.526	0.70± 0.04	2		

$2O_3 \rightarrow 3O_2$

Vol. % O_3	Vol. % O_2	λ	$10^{-2}E_T$	A	n	N*	Remarks	Lit.
9.29	90.71	250–256	115	1	3.48		Fs, Sp, B. Streaming gas	(48)
2.92	97.08	250–256	84	0.95	1.65			
1.85	98.15	250–256	95	0.98	0.76			
0.75	99.25	250–256	102	0.94	0.49			
0.47–0.18	99.53–99.82	250–256	67–188	0.752–0.248	0.28± 0.01	4		
Vol. % O_3	Vol. % N_2							(48)
2.56	97.44	250–256	108	0.98	2.64			
1.41	98.59	250–256	232	0.93	1.89			
0.65–0.167	99.35–99.833	250–256	61–215	0.877–0.267	1.08± 0.05	13		
Vol. % O_3	Vol. % He							(48)
0.429	99.571	250–256	108	0.804	1.78			
0.361	99.639	250–256	104	0.710	1.60			
Vol. % O_3	Vol. % O_2							(48)
8.49	91.51	209	115	0.857	11.15		Moist gas	
6.44	93.56	209	116	0.780	9.65			
5.66	94.34	209	118	0.733	9.00			

$2O_3 \rightarrow 3O_2$.—(*Continued*)

Vol. % O_3	Vol. % O_2	λ	$10^{-2}E_T$	A	n	N*	Remarks	Lit.
8.60	91.40	253	100	1.00	6.53		Moist gas	(48)
8.49	91.51	253	77	1.00	7.67			
7.80	92.20	253	104	1.00	6.24			
5.84	94.16	253	116	1.00	5.49			
5.43	94.57	253	144	1.00	4.75			
4.23	95.77	253	125	1.00	4.09			
3.54	96.46	253	136	1.00	3.87			
2.77	97.23	253	117	1.00	3.21			
0.91	99.09	253	124	1.00	2.05			
10.50	89.50	253	102	1.00	4.70		Moist gas	(48)
6.56	93.44	253	118	1.00	3.69			
4.47	95.53	253	106	0.99	3.17			
2.49	97.51	253	253	0.97	2.19			
2.23	97.77	253	96	0.97	3.08			
1.30	98.70	253	106	0.93	2.07			
0.80	99.20	253	83	0.86	1.66			
8.15	91.85	287	126	0.96	6.58		Moist gas	(48)
7.93	92.07	287	388	0.94	3.82			
6.27	93.73	287	433	0.93	2.90			
5.69	94 31	287	138	0.92	5.09			

$H_2 + Cl_2 \rightarrow 2HCl$

λ	E_T	A	$10^{-4}n$	Remarks	Lit.
436	323–526	0.43–0.70	2.22–2.48	Gl, Sp, Ts	(27)

$HBr \rightarrow H + Br$

p_{HBr} (mm Hg)	Mix. with	λ	$10^{-2}E_T$	A	n	N*	Remarks	Lit
20.3–30.3	H_2	209	51–67	0.496–0.667	2.13 ± 0.06	4	Fs, Sp, B. Streaming gas	(51)
120–156	H_2	209	97–101	0.969–0.983	2.07 ± 0.04	4		
11.3–14.6	N_2	209	30–46	0.289–0.383	2.03 ± 0.10	4		
28.3–30.3	N_2	209	46–66	0.635–0.676	2.10 ± 0.03	3		
386–394	N_2	209	101–104	0.985–0.987	1.96 ± 0.01	2		
226–324	N_2	209	75–109	0.946–0.981	1.92 ± 0 12	3		
267–379	N_2	209	37–51	0.495–0.608	1 99 ± 0 09	7		

$HI \rightarrow H + I$

p_{HI} (mm Hg)	Mix. with	λ	$10^{-2}E_T$	A	n	N*	Remarks	Lit.
80.2–112.7	H_2	207	124–152	0.967–0.997	1.95 ± 0.03	7	Fs, Sp, B. Streaming gas	(52)
92.3–136	H_2	253	144–189	0.929–0.982	2.06 ± 0.04	6		
260–344	H_2	282	237–273	0.655–0.706	2.09 ± 0.07	6		

$NH_3 \rightarrow N + 3H$

p (mm Hg)	λ	$10^{-2}E_T$	A	n	Remarks	Lit.
80–90	203–214	46–54	0.735–0.968	0.221 ± 0.014	Fs, Sp, B	(46)
0.5–90	203–214			0.5–0.4	Fs, Sp, Ts. Differential manometer	(29)
	206.3			0.3–0.1		
3–30	203–214			0.4(θ = 20°)	Fs, Sp, Ts	(30)
				0.6(θ = 100°)		
				0.9(θ = 200°)		
				1.4(θ = 300°)		
				2.5(θ = 400°)		
				3.3(θ = 500°)		

$Cl_2O \rightarrow Cl_2 + O$

λ	$10^{-5}E_T$	A	n	N*	Remarks	Lit.
blue-violet	1.38–3.89	0.25–0.60	2.26 ± 0.04	11	Arc lamp, F, B, Ts, or air-thermometer	(12)

λ	$10^{-2}E_T$	A	n	N*	Remarks	Lit.
430	18.7–34.2	0.40–0.67	1.995 ± 0.005	2	Gl, F	(7)

$2NOCl \rightarrow 2NO + Cl_2$

Arc lamp, F, Tp, Pressure measurement, A = *ca.* 0.90 (14)

λ	500–438 (470)				520–448 (485)	
$10^{-4}E_T$	350	350	424	424	263	320
n	0.49	0.46	0.47	0.52	0.48	0.47

Acetic aldehyde → Acetone (decomposition and polymerization)

λ	$10^{-4}E_T$	n	N*	Remarks	Lit.
UV(313)	5.02	2.3		QQ. E measured with oxalic acid + U sulfate	(15)
⋮					
UV(313)	3.08–3.53	1.80 ± 0.11	4		

* N indicates the number of experiments upon which the mean is based

Bromine + Hydrocarbons

Br_2 +	λ	E_A	A	n	N*	Remarks	Lit.
C_6H_{12}	530–440	1700	0.68 –0.93	1.02 ± 0.04	6	Gl, F, Ts.†	(38)
	476	336–532	0.595–0.938	1.08 ± [illegible].03	5	Gl, F, Ts, Titr. of Br_2	(40)
C_6H_{14}	476	258–449	0.455–0.792	32			
C_7H_{16}	476	162–502	0.285–0.885	8.4–19.6			
$C_6H_5.CH_3$	476	162–438	0.285–0.772	7.1–57			

* N indicates the number of experiments upon which the mean is based.

† Spectrophotometric for Br_2.

SOLUTIONS

$H_2O_2 \rightarrow H_2O + O$ (in H_2O)

[H_2O_2]	λ	E_A	α	A	n	Remarks	Lit.
0.037	214.4–298.0 (231)			0.025–0.92	114	Fs, Sp, Ts	(24)
0.023	210	1550	127	0.82	5.0	Fs, Sp, Ts	(25)
0.049	230	2823	75	0.88	4.9		
0.049	255.8	897	20	0.43	4.2		
0.049	280	538	3 0	0 082	3 7		

QQ, Uviol filter, Ts, $\alpha = 0.422$, $\lambda = 305 - 316$ (311) (26)

[H_2O_2]	[Z]	E_A	A	n	[H_2O_2]	[Z]	E_A	A	n
0.525		85	0.492	75.0	0.316	1.0×10^{-5}	187	0.335	69.8
0.525		249	0.492	78.9	0.317	0.5×10^{-4}	205	0.335	60.6
0.389		205	0.395	68.8	1.032	0.5×10^{-3}	338	0.736	40.8
0.319		227	0.338	59.3	0.463	0.5×10^{-3}	262	0.449	33.4
0.276		196	0.298	54.0	0.283	0.5×10^{-3}	170	0.305	36.5
0.126		105	0.151	45.8	0.170	0.5×10^{-3}	107	0.196	31.4
0.053		49	0.067	45.3	0.0548	0.5×10^{-3}	36	0.069	29.3
0.049		41	0.060	43.4	0.0293	0.5×10^{-3}	21	0.034	24.5
0.016		26	0.020	23.2	0.541	0.5×10^{-2}	252	0.503	21.3
0.311		140	0.330	74.2	0.362	0.5×10^{-2}	190	0.373	25.9
0.303*	0.5×10^{-1}	140	0.324	74.2	0.255	0.5×10^{-2}	130	0.280	26.0
0.305†	0.25×10^{-5}	211	0.325	61.4	0.1046	0.5×10^{-2}	59	0.127	26.6
0.572	0.5×10^{-5}	352	0.521	57.4	0.0512	0.5×10^{-2}	31	0.065	23.1
0.382	0.5×10^{-5}	215	0.389	68.3	0.560	0.5×10^{-1}	390	0.515	14.1
0.327	0.5×10^{-5}	215	0.344	63.0	0.388	0.5×10^{-1}	355	0.393	17.9
0.323	0.5×10^{-5}	223	0.341	76.0	0.2487	0.5×10^{-1}	172	0.274	14.8
0.297	0.5×10^{-5}	207	0.318	59.4	0.1332	0.5×10^{-1}	92	0.159	14.9
0.284	0.5×10^{-5}	205	0.307	54.2	0.0415	0.5×10^{-1}	42	0.052	12.2
0.054	0.5×10^{-5}	52	0.067	38.7	0.0280	0.5×10^{-1}	36	0.036	6.8

* Z is Na_2SO_4.

† For this and all values which follow, Z is H_2SO_4.

Cl-Compounds

Substance	[Subs.]	$10^{-5}E_T$	A	n	N*	Remarks	Lit.
ClO_2	0.317–0.0346	1.79–3.46	0.90–0.57	0.83 ± 0.02	12	Soln. in CCl_4. Arc lamp F (λ = 445), B. ±25%	(11)
Cl_2O	0.145–0.0855	1.61–2.31	0.60–0.42	0.90 ± 0.03	7		
NCl_3	0.43 –0.227	1.08–1.65	0.43–0.28	0.85–3.7			

$HI \rightarrow H + I$ (liquid)

λ	$10^{-2}E_T$	A	n	N*	Remarks	Lit.
UV (300)	73.9–77.6	1.0	1.84 ± 0.02	4	QQ, Ts, Spectrophotometric measurement.	(6)

* N indicates the number of experiments upon which the mean is based.

$HI + O_2$

QQ, Sp, Ts; constant O_2-concn.; 17.1–23.2°C; A = 1 (63); *cf.* (39, 64)

λ =			436		405		313		280	
[KI]	[HCl]	10^3 [O_2]	E_A	n	E_A	n	E_A	n	E_A	n
0.955	0.239	1.03	120	5.8	72	7.0	105	7.1	17	19.9
0.955	0.239	1.03	116	6.0	71	8.1	106	5.7	15	26.6
0.954	0.954	0.84	133	9.7	80	12.0	115	10.1	22	24.0
0.954	0.954	0.84	127	14.5	71	13.1	114	11.8	17	23.0
0.954	0.954	0.84	125	9.2	69	16.0			15	20.0
0.954	0.954	0.84	95	12.0						
0.954	0.954	0.84	95	12.8						
0.954	0.954	0.50							17	21.9
0.954	0.954	0.50							17	20.0
0.954	0.954	0.17	150	2.5	88	2.7	91	3.8	17	3.7
0.954	0.954	0.17	146	3.1	71	3.7	82	4.1	14	3.9
0.954	2.861	0.74	128	16.6	79	18.4	110	13.8	18	35.8
0.954	2.861	0.74	120	17.2	75	22.0	105	16.9	17	31.9
0.248	0.989	1.18	152	0.9	72	2.1	104	1.2	20	3.9
0.248	0.989	1.18	142	1.2	69	2.0	100	1.7	19	3.9
0.248	0.989	1.18	117	0.8			99	2.5		
0.248	0.989	1.18	114	1.2						
2.619	0.873	0.58	127	8.8	75	13.1	101	10.6	19	28.3
2.619	0.873	0.58	119	10.0	73	14.2	100	11.7	17	23.6
0.248	0.247	1.23	80	0.5	82	0.6	99	0.7	19	2.2
0.248	0.247	1.23	77	0.5	74	0.6	96	1.1	18	1.6

$HI + O_2$.—(*Continued*)

λ =			436		405		313		280	
[KI]	[HCl]	$10^3[O_2]$	E_A	*n*	E_A	*n*	E_A	*n*	E_A	*n*
0.248	0.247	1.23					93	10.6		
1.860	1.860	0.68	118	12.2	80	12.9	101	10.2	19	10.5
1.860	1.860	0.68	77	14.4	72	14.5	98		18	12.7
2.426	2.426	0.61							22	16.8
2.426	2.426	0.61							17	23.9
2.426	2.426	0.61							17	25.7
2.426	2.426	0.61							17	30.3

λ = 366

[KI]	[HCl]	$10^3[O_2]$	E_A	*n*	[KI]	[HCl]	$10^3[O_2]$	E_A	*n*
0.955	0.05	1.14	307	1.4	0.954	0.954	0.84	320	3.3
0.955	0.05	1.14	274	1.9	0.954	0.954	0.84	294	3.4
0.955	0.05	1.14	247	1.7	0.954	0.954	0.84	254	4.1
0.955	0.125	1.08	314	1.8	0.954	0.954	0.84	240	4.4
0.955	0.125	1.08	307	1.8	0.954	0.954	0.84	227	5.7
0.955	0.125	1.08	207	2.7	0.954	0.954	0.84	220	5.2
0.955	0.239	1.03	307	2.6	0.954	0.954	0.84	207	5.6
0.955	0.239	1.03	227	2.6	0.954	0.954	0.84	160	7.2
0.955	0.239	1.03	200	3.3	0.954	0.954	0.84	154	7.5
0.954	0.478	0.96	287	3.0	0.954	0.954	0.84	154	7.6
0.954	0.478	0.96	267	3.4	0.954	0.954	0.84	147	6.2
0.954	0.478	0.96	214	3.6	0.954	0.954	0.84	87	10.4
0.954	1.910	0.77	267	4.5	0.954	0.954	0.84	80	11.0
0.954	1.910	0.77	260	4.3	0.954	0.954	0.84	48	11.6
0.954	1.910	0.77	247	5.1	0.954	0.954	0.84	45	10.9
0.954	2.861	0.74	334	4.3	0.954	0.954	0.84	23	25.9
0.954	2.861	0.74	300	5.2	0.954	0.954	0.84	23	18.7
0.954	2.861	0.74	274	6.1	0.954	0.954	0.84	23	21.2
0.248	0.989	1.18	320	0.9	0.954	0.954	0.84	9.3	26.0
0.248	0.989	1.18	294	1.0	0.954	0.954	0.84	9.3	41.5
0.248	0.989	1.18	227	1.1	0.954	0.954	0.50	327	3.0
0.490	0.977	1.02	327	3.1	0.954	0.954	0.50	287	3.8
0.490	0.977	1.02	320	3.0	0.954	0.954	0.50	274	3.8
0.490	0.977	1.02	254	4.1	0.954	0.954	0.17	307	1.6
1.786	0.915	0.69	300	4.2	0.954	0.954	0.17	287	1.4
1.786	0.915	0.69	274	4.0	0.954	0.954	0.17	267	1.7
1.786	0.915	0.69	254	4.7	1.860	1.860	0.68	280	4.5
2.619	0.873	0.58	307	3.7	1.860	1.860	0.68	267	4.2
2.619	0.873	0.58	274	3.7	1.860	1.860	0.68	254	4.5
2.619	0.873	0.58	267	5.2	2.426	2.426	0.61	294	5.0
0.248	0.247	1.23	294	0.3	2.426	2.426	0.61	280	5.0
0.248	0.247	1.23	267	0.3	2.426	2.426	0.61	267	4.8
0.248	0.247	1.23	254	0.3					
0.487	0.487	1.06	307	1.8	λ = 254				
0.487	0.487	1.06	300	2.2	0.954	0.954	0.84	39	12.0
0.487	0.487	1.06	260	2.5					

Hydrolysis of $PtCl_4(OH)_2H_2$
QQ, Sp, Ts; conductivity measurements (7)

$10^4[Pt]$	λ	E_A	$10^{-7}\alpha$	*A*	*n*
0.2	253.6	6.4	0.63	0.14	0.3
0.5	253.6	13.6	0.63	0.29	0.9
0.75	253.6	17.9	0.63	0.38	1.5
1	253.6	21.4	0.63	0.46	1.8
1.5	253.6	27.2	0.63	0.58	2.6
2	253.6	33.6	0.63	0.72	3.4
1	237.8	0.96	0.82	0.33	4.2
1	240.0	3.3	0.80	0.31	3.2
1	248.2	6.4	0.70	0.28	2.5
1	253.6	19.8	0.63	0.25	1.8
1	265.5	18.3	0.47	0.19	1.5
1	297.0	34.8	0.16	0.07	0.30
1	310.0	119	0.095	0.04	0.09
1	366.0	159	0.019	0.009	0.035
1	435.0	123	0.0052	0.003	0.008
1	546.0	129	0.0022	0.001	0.003

$2Fe^{+++} + 2I^- \leftrightarrows 2Fe^{++} + I_2$ (displacement of equilibrium) (42)

	λ	$10^{-2}E_T$	*A*	*n*
QQ, F, Ts	579	365	0.61	0.93

$2K_3Co(C_2O_4)_3 = 2CoC_2O_4 + 3K_2C_2O_4 + 2CO_2$ (aqueous solution)
QQ, F, Ts; extinction measurement (45)

λ =	436			405			366		
$[K_3CoOx_3]$	E_A	*A*	*n*	E_A	*A*	*n*	E_A	*A*	*n*
0.005	12.3	0.47	0.53	13.0	0.83	0.82	16.8	0.86	1.30
0.002	6.0	0.23	0.43	8.0	0.51	0.71	10.7	0.55	1.30
0.001	3.1	0.12	0.71	4.7	0.30	1.00	6.4	0.33	1.50
0.0002	0.8	0.03	0.60	1.1	0.07	0.94	1.2	0.06	1.79

$Cl_2 + 2CBrCl_3 = 2CCl_4 + Br_2$ (dilution with CCl_4)

$[CBrCl_3]:[CCl_4]$	λ	$10^{-2}E_A$	*n*	N*	Remarks	Lit
1:0	440–391 (410)	170	0.94 ± 0.03	15	Gl,F, Ts. Spectrophotometric for Br_2. A = 0.50–0.70	(38)
1:0	468–440 (449)	156	0.90 ± 0.10	6		
1:4.07	blue and violet		0.98		Gl, F. Relative energy measurement. Spectrophotometric for Br_2	(22)
1:9.15			0.94			
1:19.3			0.94			
1:39.7				1.04		
1:80.3				0.87		

Diluted with $SiCl_4$

$CBrCl_3:SiCl_4$	*n*	$CBrCl_3:SiCl_4$	*n*
1:0.889	0.90	1:64.3	0.77
1:2.48	0.87	1:162	0.67
1:7.24	0.96	1:324	0.57
1:16.33	0.94	1:647	0.39
1:32.3	0.98		

$2CBrCl_3 + O_2 = 2COCl_2 + Br_2 + Cl_2$ (22)
Sensitized with Br_2, 880 g/l.
$\lambda = 436, 405; E_A = 454; A = 0.87$

System	*n*	N*	Remarks
Pure $CBrCl_3$, satd. with O_2......	1.07		Uviol lamp, F, Ts, spectrophotometric for Br_2; ± 20%
1 vol. $CBrCl_3$ and 15 vols. CCl_4, satd. with O_2................	0.71 ± 0.05	4	
1 vol. $CBrCl_3$ and 15 vols. CCl_4, satd. with air................	0.88 ± 0.06	11	

Hydrolysis of monochloro- and monobromoacetic acids QQ, Sp, Ts. λ = 254. Electrometric titr. RG constant. *n*, ± 11 – 18% (43).

Substance	[Subs.]	E_A	λ	*A*	*n*
$ClCH_2CO_2H$..............	0.5	72	0.84	0.86	1.05
	0.3	61	0.94	0.72	0.95
$BrCH_2CO_2H$..............	0.02	66	22	0.87	0.35
	0.01	53	27.5	0.72	0.32
$BrCH_2CO_2Na$..............	0.02	51			0.47
(in 0.02*N* NaOH)...........	0.02	48			0.54
(in 0.04*N* Na_2SO_4)..........	0.02	43			0.36

Organic acids + Br_2

Br_2+	λ	E_A	*A*	*n*	Remarks	Lit.
Lactic acid.........	530–490(500)	8.10^3	0.70	0.22	Gl, F, Ts, or radio-micrometer	(18)
Ca lactate..........	530–490(500)	8.10^3	0.70	0.6–1.0		(18)
Tartaric acid						
$[Br_2] = 0.015$.....	490–450	360		*ca.* 12		(20)
$[Br_2] = 0.0325$....	490–450	360		*ca.* 4		(20)
Cinnamic acid (in CCl_4)............	650–390(470)	32	0.17	436		(21)
Stilbene (in CCl_4)...	650–390(470)	32	0.17	290		(21)

Oxidation with I_2 (37)

I_2	λ	$10^3 E_T$	*A*	*n*	Remarks
K formate..........	460–316(388)	11	0.21	8.3	Gl, radio-micrometer; θ = 31°C
K oxalate...........		11	0.19	1.2	
$FeSO_4$..............		13.3	0.32	1.95	
$NaNO_2$.............		9.3	0.16	0.7	

o-Nitrobenzaldehyde (in acetone) (58)

λ	E_A	*A*	*n*	N*	Remarks
436	10.4– 80	0.035–0.245	0.469 ± 0.026	10	QQ, F, B, conductivity
405	600 – 820	0.606–0.975	0.473 ± 0.020	7	
366	810 –1140	0.76 –1.00	0.533 ± 0.015	14	

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* N indicates the number of experiments upon which the mean is based.

λ	$10^5 E_T$	A	n	Remarks	Lit.
o-Nitrobenzaldehyde → *o*-Nitrosobenzoic acid (in acetone)					
405	67	1	1.3	QQ, F, Sk, conductivity	(31, 60)
366	25	1	3.2		
Anthracene → Dianthracene (in phenetole)					
400	23	1	0.49	QQ, glass filter	(28, 59); *cf.* (5)
β-Methylanthracene → Dimethyldianthracene (in phenetole)					
400	23	1	0.39	QQ, glass filter	(28, 59); *cf.* (5)

Acetone + H_2O

System	λ	A	n	Remarks	Lit.
Acetone + H_2O (1 M)	298–214.4(231)	0.38–1.00	1175	Fs, Ts, Titr.	(24)

%	λ	$10^4 E_T$	n	Remarks	Lit.
0.3	UV (313)	3.8	0.06	QQ. E measured with oxalic acid + U sulfate.	(15)
15		7.2	0.15		

K oxalate + I_2; λ = 486, blue. n = *ca.* 0.11 (3)

λ	$10^5 E_T$	A	n	Remarks	Lit.
Oxalic acid + Uranyl nitrate (both 0.001 M)					
253.6	37.1	0.80	47	QQ, Sp, Ts, $\alpha = 2.3 \times 10^6$	(8)
Oxalic acid (0.033 M) + Uranyl sulfate (0.016 M)					
492.7–407.2(423)	10.6	0.72	1.07 ± 0.02	Incand. lamp. F.*	(16)

* Spectrophotometric for the energy. Titr. ± 20%.

Oxalic acid + Uranyl sulfate (1)

λ	$10^{-2} E_A$	n	Remarks
356	328	0.027	QQ. Titr. with $KMnO_4$.

λ	$10^{-6} E$	A	n	Remarks	Lit.
313	1.18	0.43	1.06 ± 0.05	QQ, Ts.*	(15)

* Titr. with $KMnO_4$. [acid] = 0.1N. [sulfate] = 0.01M.

λ	A	n	λ	A	n
Fumaric acid → Maleic acid (in H_2O) (53*)					
0.0102 M			0.00306 M		
207	1	0.104	207	1	0.080
253	1	0.098	253	0.95	0.087
282	0.857	0.134	282	0.553	0.099
Maleic acid → Fumaric acid (in H_2O) (53*)					
0.0102 M			0.00514 M		
207	1	0.032	207	1	0.037
253	0.99	0.043	253	0.97	0.049
282	0.725	0.032	282	0.531	0.035

* Fs, Sp, B, stirring, conductivity.

Ethyl malate + Br_2 (in CCl_4)

QQ. Analysis by M. P. determination. RG proportional to E_A, independent of Br_2 (limits 1:9) and of CCl_4 (limits 1:5). 18°C. TK for the absorbed energy = 2 (17).

λ................	557	436	366
n................	429	565	684.5

Allocinnamylideneacetic acid (catalysed by I_2)

[Acid] (mol/l)	λ	$10^{-3} E_A$	n	Remarks	Lit.
0.171	500	25	0.36	Gl, F	(19)
0.342	500	25	0.83		

CO_2-Assimilation

λ	$10^5 E_T$	A	n	Remarks	Lit.
610–690(600)	730–1570	1	0.226	QQ or Gl, Sp, or F, B.	(55)

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(1) Anderson and Robinson, *1*, **47**: 718; 25. (2) Berthelot and Gaudechon, *34*, **156**: 707; 13. (3) Berthoud and Bellenot, *42*, **21**: 308; 24. (4) Bodenstein, *7*, **85**: 329; 13. (5) Bodenstein, *7*, **87**: 93; 14. (6) Bodenstein and Lieneweg, *7*, **119**: 123; 26. (7) Bodenstein and Kistiakowski, *7*, **116**: 371; 25. (8) Boll, *Thesis*, Paris, 1914. *34*, **156**: 691; 13. **157**: 115; 13. (9) Bonhoeffer, *96*, **13**: 94; 23.

(10) Book and Eggert, *9*, **29**: 521; 23. (11) Bowen, *4*, **123**: 1199; 23. (12) Bowen, *4*, **123**: 2328; 23. (13) Bowen, Hartley, Scott and Watts, *4*, **125**: 1218; 24. (14) Bowen and Sharp, *4*, **127**: 1026; 25. (15) Bowen and Watts, *4*, **1926**: 1607. (16) Büchi, *7*, **111**: 304; 24. (17) Eggert, *63*, **25**: 19; 24. (18) Ghosh and Basu, *482*, **2**: 39; 25. (19) Ghosh and Gupta, *482*, **2**: 241; 25.

(20) Ghosh and Mukherjee, *482*, **2**: 165; 25. (21) Ghosh and Purkayestha, *482*, **2**: 261; 25. (22) Grüss, *9*, **29**: 144; 23. (23) Hatt, *7*, **92**: 513; 18. (24) Henri and Wurmser, *34*, **156**: 1012; 13. *51*, **3**: 320; 13. (25) Henri and Wurmser, *34*, **157**: 126; 13. (26) Kornfeld, *99*, **21**: 66; 21. (27) Kornfeld and Müller, *7*, **117**: 242; 25. **118**: 476; 25. (28) Krüger, *Diss.*, Berlin, 1913. (29) Kuhn, *34*, **177**: 956; 23.

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(40) Pusch, *9*, **24**: 336; 18. (41) Rideal and Norrish, *5*, **103**: 366; 23. (42) Rideal and Williams, *4*, **127**: 258; 25. (43) Rudberg, *96*, **24**: 247; 24. (44) Sebelien, *Norske Vid. Selsk. Skr. Math.-naturv. Kl.*, **1904**: No. 9. (45) Vránek, *9*, **23**: 336; 17. (46) Warburg, *76*, **1911**: 746. (47) Warburg, *76*, **1912**: 216. (48) Warburg, *76*, **1913**: 644. (49) Warburg, *76*, **1914**: 872.

(50) Warburg, *76*, **1915**: 230. (51) Warburg, *76*, **1916**: 314. (52) Warburg, *76*, **1918**: 300. (53) Warburg, *76*, **1919**: 960. (54) Warburg, *9*, **27**: 133; 21. (55) Warburg and Negelein, *7*, **106**: 191; 23. (56) Weigert, *7*, **80**: 78; 12. (57) Weigert, *Nernst Festschrift*, 464; 12. (58) Weigert and Brodmann, *83*, **21**: 453; 26. *7*, **120**: 24; 26. (59) Weigert and Krüger, *7*, **85**: 579; 13. **86**: 383; 14.

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Abbreviations:

QQ	Quartz mercury vapor lamp.
Sp.	Spectral purification of monochromatic radiation.
F	Light filter (wave filter).
UV	Ultra-violet radiation.
λ	Wave length in $\mu\mu$.
I	Intensity.
RV	Reaction velocity.
C	Concentration.
t	Temperature, °C
TC	Temperature coefficient.

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123: 2752; 23. ($2O_3 \rightarrow 3O_2$. Incandescent lamp. In mixtures with O_2, RV proportional to $[O_3]^2$. Accelerated by H_2.) (76) Griffith and MacWillie, *4*, **123**: 2767; 23. ($2O_3 \rightarrow 3O_2$. Incandescent lamp. Accelerated by He, A, N_2, CO, CO_2.) (77) Gros, *7*, **37**: 157; 01. (Leuco compounds + O_2. Light sensitivity of fluoresceins and derivatives.) (78) Halban and Geigel, *7*, **96**: 233; 20. (Coloration and decoloration of tetrabenzoylethylene. Sunlight, Uviol lamp. O_2 retardation.) (78.5) Hartung, *4*, **125**: 2198; 24. (AgBr. Sunlight. RV.) (79) Hatt, *7*, **92**: 513; 18. (Uranyl formate. Sunlight, incandescent lamp, QQ. Retardation by uranous salts. Kinetics. Added substances.)

(80) Hecht, *223*, **3**: 1; 20. (Bleaching of visual purple [solution]. Incandescent lamp. Monomolecular.) (81) Henri and Ranc, *34*, **154**: 1261; 12. (Glycerol + H_2O_2. UV.) (82) Henri and Wurmser, *34*, **157**: 126; 13. ($H_2O_2 \rightarrow H_2O + O$. $\lambda = 280 - 210$. Monomolecular. RV proportional to the absorbed energy.) (83) Hill, *83*, **20**: 109; 24. ($3SO_2 = 2SO_3 + S$. Uviol lamp. Unilateral F. Sensitive to 313$\mu\mu$.) (84) Holmes, *1*, **44**: 1002; 22. (Triphenylmethanesulfonic acid. Equilibrium between the colored and colorless forms. Change with λ.) (85) Holmes, *483*, **13**: 188, 197; 24. (Oxalic acid and uranyl salts as chemical photometer in actinometer.) (86) Jaeger and Berger, *64P*, **23**: 84; 21. *70*, **40**: 153; 21. (K cobaltioxalate. QQ. RV independent of *C*. Salt effect.) (87) Job and Emschwiller, *34*, **179**: 52; 24. (Ethyl iodide. Sensitivity limit at 410 $\mu\mu$.) (88) Jodin, *6*, **27**: 426; 82. (Ferric oxalate. Daylight.) (89) Jodlbauer and Tappeiner, *25*, **38**: 2602; 05. (Eder's solution. Dyestuffs as catalyzers).

(90) Jodlbauer and Tappeiner, *484*, **82**: 520; 05. (KI + O_2, Eder's solution, $As_2O_3 + O_2$. Catalyzers.) (91) Jorissen and Reicher, *7*, **31**: 142; 99. (Oxalic acid + O_2 + various metallic salts. Daylight, sunlight. Effect of *C* of catalyst.) (92) Kailan, *57*, **33**: 1305; 12. *25*, **46**: 1628; 13. (*o*-Nitrobenzaldehyde → *o*-nitrosobenzoic acid.) (93) Kailan, *7*, **98**: 495; 21. (H_2O_2. QQ. Effect of H_2SO_4.) (94) Kastle and Loevenhart, *1*, **21**: 262; 99. (H_2O_2 + formaldehyde. Sunlight. Bimolecular. TC.) (95) Kiss, *70*, **42**: 665; 23. ($NOCl \rightarrow NO + Cl$. Incandescent lamp. Monomolecular. TC.) (96) Kistiakowsky, *7*, **35**: 431; 00. ($H_2O_2 + K_3Fe(CN)_6 + K_4Fe(CN)_6$. Arc lamp. Partially monomolecular. After effect.) (97) Kistiakowsky, *169*, **23**: 1915. *10*, **4**: 924; 22. ($H_2O_2 + K_3Fe(CN)_6 + K_4Fe(CN)_6$. Monomolecular. After effect.) (98) Klimenko, *25*, **28**: 2558; 95. ($Cl_2 + H_2O$. Catalyzers.) (99) Landau, *34*, **152**: 1308; 11. (Lactic acid. UV.)

(100) Landau, *34*, **155**: 403; 12. (Polymerization of C_2H_4. QQ.) (101) Landau, *34*, **156**: 1894; 13. (Oxalic acid + uranyl salts. UV.) (102) Langmuir, *1*, **42**: 2190; 20. (Radiation hypothesis and chemical action.) (103) Lasareff, *8*, **24**: 661; 07. (Fading of dyestuffs. Nernst lamp. Sp. Rotating sector. Sensitivity to various λ proportional to absorbed energy.) (104) Lasareff, *8*, **37**: 812; 12. (Fading of dyestuffs. Nernst lamp. Sp. Several absorption bands.) (105) Lasareff, *7*, **78**: 661; 12. **79**: 638; 12. (Methylene blue. Nernst lamp. Sp. Color sensitivity.) (106) Lasareff, *134*, **1919**: 239. (Kinetics. Theory.) (107) Lasareff, *7*, **98**: 94; 21. (Fading of dyestuffs. High O_2 pressure. Relation between RV and O_2 pressure.) (108) Lasareff and Perrin, *34*, **177**: 1436; 23. (RV for periodically fluctuating *I*.) (108.5) Lasareff, *83*, **21**: 475; 26. *7*, **120**: 58; 26. (RV and λ. Fading of dyestuffs.) (109) Le Blanc, Andrich and Kangro, *9*, **25**: 229; 19. ($SO_2Cl_2 \rightleftharpoons SO_2 + Cl_2$. Spark gap, QQ, Sp, F. Extinction measurements. Equilibrium.)

(110) Leighton, *50*, **17**; 205; 13. (Fehling's solution + hydroquinone. Color sensitivity.) (111) Lemoine, *6*, **6**: 433; 95. ($FeCl_3$ + oxalic acid. Sunlight. Relation between RV and absorption. TC. RV proportional to *I*.) (112) Lemoine, *34*, **173**: 192; 21. (Oxalic acid + HIO_3. Sunlight. Kinetics.) (113) Lewis, *4*, **101**: 2371; 12. ($NaOCl \rightarrow NaCl + O$. Uviol lamp. $t = 25$. Stirring. Monomolecular in neutral and alkaline solution.) (114) Lewis and MacKeown, *1*, **43**: 1288; 21. (Radiation theory of thermal reactions.) (115) Lifschitz and Joffé, *25*, **52**: 1919; 19. (Di- and triphenylmethane derivatives in solution. UV. Reversible transformations.) (116) Lifschitz and Joffé, *7*, **97**: 426; 21. (Triarylmethane derivatives. UV. Equilibrium between colorless and colored forms.) (117) Lind, *50*, **28**: 55; 24. ($H_2 + Br_2$. Arc lamp. $t = 250$.) (118) Lombard, *27*, **7**: 186; 10. (KNO_3. QQ. Kinetics.) (119) Luther, *7*, **30**: 628; 99. (AgCl. Daylight. Stationary state.)

(120) Luther and Forbes, *1*, **31**: 770; 09. (Quinine + CrO_3. Uviol lamp, F. Kinetics. Spectral effect additive. Color sensitivity.) (121) Luther and Goldberg, *7*, **56**: 43; 06. (O_2 retardation in Cl_2 reactions.) (122) Luther and Plotnikow, *7*, **61**: 513; 08. (Pseudoreversible reactions. $HI + H_3PO_3 + O_2$.) (123) Luther and Weigert, *7*, **51**: 297; 05. **53**: 385; 05. (Anthracene → dianthracene. Arc lamp. RV and stationary state. TC. RV proportional to *I*.) (124) Marshall and Taylor, *58*, **112**: 937; 23. ($H_2 + Cl_2$. Reaction mechanics.) (125) Mathews and Curtis, *50*, **18**: 166; 14. (H_2O_2. Uviol lamp. Monomolecular. Negative catalyzers. TC.) (126) Mathews and Curtis, *50*, **18**: 641; 14. (KIO_3. QQ. Catalysis.) (127) Mathews and Dewey, *50*, **17**: 211; 13. (Oxalic acid + uranyl salts. QQ.) (123) Mathews and Weeks, *1*, **39**: 635; 17. ($Na_2SO_3 + O_2$. QQ. Negative catalyzers. (129) Mathews and Williamson, *1*, **45**: 2574; 23. (Acetylchloroaminobenzene. UV. Kinetics. After effects in nonaqueous solvents.)

(130) Matuschek, *136*, **25**: 411, 522; 01. ($K_3Fe(CN)_6$. Daylight.) (131) Milbauer, *7*, **86**: 564; 14. ($Cl_2 + H_2O$. Catalyzers.) (131.1) Moore and Noyes, *1*, **46**: 1367; 24. ($3O_2 \rightarrow 2O_3$. Sensitization with Hg.) (131.2) Norrish and Rideal, *4*, **127**: 787; 25. ($H_2 + O_2$. Sensitization with Cl_2. QQ. Glass filter. RV proportional to $[O_2] \times [Cl_2]$.) (131.3) Norrish, *4*, **127**: 2317; 25. ($H_2 + Cl_2$. Induction period.) (131.5) Noyes, *1*, **47**: 1003; 25. ($N_2 + 3H_2 \rightarrow 2NH_3$. Sensitization with Hg. QQ, F. $\lambda >$ 215$\mu\mu$.) (132) Noyes and Kouperman, *1*, **45**: 1398; 23. (Solid oxalic acid. UV. Induction period. Constant velocity.) (132.5) Padoa, *36*, **55**: 87; 25. (TC and λ.) (132.6) Padoa, *83*, **21**: 573; 26. *7*, **120**: 202; 26. (Spectral effect not additive.) (133) Padoa and Foresti, *22*, **22 II**: 576; 13. *36*, **45 I**: 21; 15. (Phototropy. Sunlight. Equilibrium at various temperatures.) (134) Padoa and Minganti, *22*, **22 II**: 500; 13. *36*, **45 I**: 15; 15. (Phototropy. Coloration monomolecular, decoloration in dark bimolecular. RV proportional to *I*. TC.) (135) Padoa and Zazzaroni, *22*, **24 I**: 828; 15. (Phototropy. Coloration bimolecular, decoloration monomolecular.) (136) Padoa and Vita, *36*, **54**: 147; 24. ($HI + O_2$, ferric oxalate, Eder's solution. Arc lamp, F. Spectral effect not additive.) (136.5) Perrin and Choucroun, *34*, **178**: 1401; 24. (Methylene blue, eosin in glycerol. RV and *C*.) (137) Pinnow, *25*, **34**: 2528; 01. *42*, **63**: 239; 01. ($HI + O_2$. Quinine as catalyst.) (138) Piva, *36*, **45 I**: 219; 15. ($CO + Br_2$. Sunlight.) (139) Plotnikow, *7*, **58**: 214; 07. **64**: 215; 08. ($HI + O_2$. Uviol lamp. RV proportional to concentration of O_2. Criticism by Winther, *137*, **2**: No. 2; 20.)

(140) Plotnikow, *7*, **78**: 573; 12. **79**: 641; 12. *9*, **19**: 753; 13. (Br_2 + benzene, cinnamic acid. Uviol lamp. Color sensitivity. Criticism by Bruner, *9*, **19**: 555; 13.) (141) Plotnikow, *99*, **19**: 1; 19. (Br_2 + *α*-phenylcinnamic nitrile. Uviol lamp. Equilibrium. Reaction order. Change in *I*.) (142) Plotnikow, *99*, **19**: 22; 19. ($Cl_2 + CCl_4$. Uviol lamp. Periodic reaction. Criticism by Grüss, *9*, **29**: 144; 23, and Benrath and Hertel, *99*, **23**: 30; 24.) (142.5) Plotnikow, *99*, **23**: 79; 24. (Aliphatic compounds + Cl_2; *cf.* Benrath and Hertel (12).) (143) Puxeddu and Vodret, *36*, **52 I**: 229; 22. ($FeCl_3$ + ethyl ether. Sunlight, arc lamp. Approximately monomolecular.) (144) Rankin, *50*, **11**: 1; 07. ($S_\lambda \rightleftharpoons S_\mu$.) (145) Reddelien, *Diss.*, Leipzig, 1908. (Phototropy. Kinetics. Catalysis.) (146) Regener, *8*, **20**: 1033; 06. *Diss.*, Berlin, 1905. ($2O_3 \rightarrow 3O_2$. UV. Monomolecular.) (147) Reynolds and Taylor, *4*, **101**: 131; 12. (HNO_3 vapor. Sunlight. Reversible decomposition.) (148) Richardson, *4*, **65**: 450; 94. (Oxalic acid + O_2. Daylight. Approximately monomolecular.) (149) Rideal and Norrish, *5*, **103**: 342; 23. ($KMnO_4$. UV. Pseudoreversible reaction. Monomolecular in neutral solution, constant velocity in acid solution. TC *ca.* 1.) (149.5) Rideal and Williams, *4*, **127**: 258; 25. ($Fe^{+++} + I^- \rightleftharpoons Fe^{++} + I$. Displacement of equilibrium. Incandescent lamp, QQ, F. Sensitive to $\lambda = 550–650$ and UV. I_2 is active. Effect of KCl. TC.)

(150) Roloff, *7*, **13**: 327; 94. (Eder's solution. O_2 retardation. Oxalic acid + Br_2.) (151) Ross, *1*, **28**: 786; 06. (KI. UV. Chlorates, bromates, organic Fe compounds. Constant velocity. Calculations by Kailan, *57*, **34**: 1209; 13.) (152) Sanyal and Dhar, *93*, **128**: 212; 23. (Eder's solution. Sunlight. RV proportional to concentration of oxalate, independent of $HgCl_2$.) (153) Sasaki, *429*, **5**: 315; 22. *93*, **122**: 61; 22. ($Fe^{+++} + I^- = Fe^{++} + I$. Incandescent lamp. Increasing I reverses the reaction.) (154) Schall, *99*, **10**: 89; 12. (*p*-Phenylenediamine nitrate paper. Only sensitive to UV. Measurement of action of UV.) (155) Schlenk and Herzenstein, *25*, **43**: 3541; 10. (Formation and decomposition of diphenylbiphenylmethyl. Sunlight. Reversible.) (156) Slator, *7*, **45**: 513; 03 ($Cl_2 + C_6H_6$. Sunlight. Kinetics. Catalysis.) (157) Stobbe, *13*, **359**: 1; 08. (Triphenylfulgide. Phototropic transition. Discussion of effect of λ, *t*, and *I*.) (158) Stobbe and Schmidt, *99*, **20**: 57; 20. (Alkyliodide + O_2. QQ. Time curves.) (159) Stoermer, *25*, **42**: 4865; 09. (Transformation of stereoisomers.)

(160) Stoermer and Heymann, *25*, **46**: 1249; 13. (Transformation of halogen cinnamic acids in UV. Curves for RV.) (161) Strachoff, *53*, **48**: 824; 16. *99*, **18**: 227; 19. *10*, **4**: 925; 22. ($HI + O_2$. Autocatalysis.) (162) Straub, *486*, **51**: 1093; 04. *277*, **51**: 383; 04. (KI + O_2 + catalyzers. False equilibrium.) (162.5) Suryanarayana, *194*, **2**: 12; 24. (KI, no reaction to UV. KNO_3, $KClO_3$, reversible reaction, UV.) (163) Swensson, *19*, **7**: No. 25; 20. (H_2O_2. UV. Monomolecular. No after effects.) (164) Swensson, *99*, **20**: 206; 21. (Br_2 + aromatic hydrocarbons. Uviol lamp. Kinetics. Added substances.) (165) Szilard, *99*, **4**: 127; 06. (CHI_3 in $CHCl_3$. Autocatalysis. After effect. Course of the reaction.) (166) Taylor and Lewis, *1*, **46**: 1606; 24. (Dianthracene → anthracene. Sensitive to red. Extinction measurements.) (166.5) Taylor, *83*, **21**: 560; 26. *7*, **120**: 183; 26. (Sensitization of C_2H_4, CO, O_2, N_2O with Hg.) (167) Thomas, *Diss.*, Freiberg, 1908. (Oxidation of Na_2S, Cu_2Cl_2, Cu_2Br_2, Na_2SO_3, $FeSO_4$, HI, pyrogallol. $CO + Br_2$. Retardation by radiation. Visible light.) (168) Tian, *34*, **151**: 1040; 10. **156**: 1879; 13. (H_2O_2. QQ. Monomolecular.) (169) Tian, *16*, **5**: 248; 16. (H_2O_2. UV. Monomolecular. Effect of acids and bases. RV proportional to *I*. $2H_2O \rightarrow 2H_2 + O_2$. Kinetics. Effect of acids and bases.)

(170) Tolman, *1*, **42**: 2506; 20. **45**: 2285; 23. (TC. Theory.) (171) Tramm, *7*, **105**: 356; 23. ($3O_2 \rightleftharpoons 2O_3$, $H_2 + Cl_2 \rightleftharpoons 2HCl$, HBr, HI, $CO + Cl_2$, $SO_2 + Cl_2$, $CO + O$, $H_2 + O_2$. Extremely dry gases.) (172) Trautz, *63*, **7**: 899; 06. (Pyrogallol + O_2, $Na_2S + O_2$. TC.) (173) Trautz, *9*, **13**: 550; 07. ($Na_2S + O_2$. Retardation by light.) (174) Trautz, *9*, **21**: 336; 15. (SO,

+ Cl_2. QQ. Uviol lamp. Bimolecular. TC.) (175) Varahalu, Ram and Rao, *194*, **1**: 107; 24. (Phototropy of Hg compounds.) (176) Volmar, *34*, **178**: 697; 24. (Calculations of effective λ.) (177) Volmer and Riggert, *7*, **100**: 502; 22. (Anthracene dissolved in hexane. Splitting off of an electron. QQ. Equation for RV.) (178) Warburg, *76*, **1918**: 1228. (KNO_3. UV. Quantum sensitivity. Criticism by Anderson, *1*, **46**: 797; 24. *cf.* Robinson, *1*, **46**: 1834; 24.) (179) Weigert, *8*, **24**: 55; 07. ($COCl_2 \rightleftharpoons CO + Cl_2$. UV. Equilibrium at high temperature.)

(180) Weigert, *8*, **24**: 243; 07. (Sensitizing gas reactions with Cl_2. UV.) (181) Weigert, *9*, **14**: 591; 08. ($2O_3[+Cl_2] \rightarrow 3O_2$. QQ. Glass filter. Equation for RV.) (182) Weigert, *7*, **63**: 458; 08. (Anthracene → dianthracene. Calculations from earlier researches.) (183) Weigert, *7*, **80**: 78; 12. *9*, **18**: 654; 12. ($2O_3 \rightarrow 3O_2$. UV. Kinetics.) (184) Weigert, *99*, **11**: 381; 12. (Efficiency factor of absorbed energy.) (185) Weigert, *Nernst Festschrift*, 464; 12. (O_2 retardation. Calculations by Winther, *7*, **108**: 271; 24.) (186) Weigert, *25*, **46**: 815; 13. ($O_3 + H_2$. UV. Kinetics.) (187) Weigert and Bohm, *7*, **90**: 189; 15. ($O_3 + H_2$. UV. RV in relation to *C*. TC. Spectral effect not additive.) (188) Weigert and Kellermann, *7*, **107**: 1; 23. *76*, **1922**: 315; *9*, **28**: 456; 22. ($H_2 + Cl_2$. Draper effect.) (189) Weigert and Kummerer, *25*, **46**: 1207, 1884; 13. *See also* Kummerer, *Diss.*, Berlin, 1914. (*o*-Nitrobenzaldehyde → *o*-nitrosobenzoic acid. λ = 405 and 366. Constant velocity at total absorption. RV proportional to *I*. TC *ca.* 1.)

(190) Wigand, *7*, **65**: 442; 09. ($S\lambda \rightleftharpoons S\mu$. Arc lamp.) (191) Wigand, *7*, **77**: 423; 11. ($S\lambda \rightleftharpoons S\mu$. QQ. Glass filter. Solution and fusion.) (192) Wildermann, *7*, **42**: 257; 03. ($CO + Cl_2$. Acetylene lamp. Kinetics.) (193) Winther, *99*, **7**: 409; 09. **8**: 197, 237; 10. **9**: 205; 11. (Eder's solution. Catalysis. Color sensitivity. Mechanics.) (194) Winther, *99*, **8**: 135; 10. (Ferric oxalate. UV. Inversion.) (195) Winther, *99*, **11**: 60; 12. *9*, **18**: 138; 12. ($Hg^{++} + Fe^{++} \rightleftharpoons Hg^{+} + Fe^{+++}$. UV. Light accumulator.) (196) Winther, *137*, **2**: No. 1; 20. ($H_2O_2 + K_4Fe(CN)_6$. UV. Constant velocity.) (197) Winther, *137*, **2**: No. 2; 20. ($HI + O_2$. $\lambda = 436 - 313$. Autocatalysis.) (198) Winther and Oxholt-Howe, *99*, **13**: 89; 13. (Eder's solution, eosin. False equilibrium.) (199) Winther and Oxholt-Howe, *99*, **14**: 196; 14. (Organic Fe salts. $\lambda = 436 - 313$. Kinetics.)

(200) Wittwer, *8*, **94**: 597; 55. **97**: 304; 56. **106**: 266; 59. ($Cl_2 + H_2O$. Daylight. Monomolecular. Criticism by Bunsen and Roscoe, *8*, **96**: 373; 55.) (201) Wurmser, *34*, **171**: 820; 20. (CO_2 assimilation. Daylight. Color sensitivity.)

THE ABSORPTION SPECTRA OF DYES

Walter C. Holmes

ARRANGEMENT, SYMBOLS, UNITS AND CONVENTIONS

The following tables are designed to supplement the tables of spectroscopic data on technical synthetic dyes supplied by Formánek and Grandmougin in their "Untersuchung und Nachweis organischer Farbstoffe auf spektroskopischem Wege" and the review of the spectroscopy of natural coloring matters found in Kayser's "Handbuch der Spektroskopie."

The primary aim has been that of affording a ready means of ascertaining what data are available for any given coloring matter. With this end in view the selection of dyes has been made as comprehensive and the literature references as complete as possible. There have also been recorded numerous data on the spectral location of the maxima of absorption bands, under various conditions, in the ultra-violet, visible and infra-red, which will usually prove adequate to those interested in the identification of dyes or in the correlation of color and constitution. If a more complete qualitative or quantitative definition of the absorption is desired it may, in numerous instances, be obtained readily by consulting the references recorded.

Synthetic dyes have been arranged by classes in twelve tables and listed in the order of their constitutional formulae. Natural coloring matters have been listed in alphabetical sequence in Table 13. The dye formulae are followed by the scientific names of the coloring matters, supplemented, in some instances, by names of more common usage and by C. I. (Colour Index of the Society of Dyers and Colourists) numbers.

All absorption maxima in the ultra-violet and visible spectrum are recorded in terms of wave length in millimicrons. Italicized values refer to the principal bands and bracketed values to relatively insignificant bands. (The common bracketing of several values signifies multiple maxima in a single band.) The absorption data are followed by reference numbers to the source from which they were taken, together with further reference numbers to other literature on the dye in question which may prove of further interest. References followed by (q) contain data on the more definitely quantitative aspect of the absorption.

In instances in which various data of independent origin have been available the recorded values are those which have appeared the more reliable to the writer. The question of the dependence which may be placed upon the greater portion of the material presented is left to the discrimination of the reader. Since data

Les tables suivantes ont pour objet de compléter les tables des données spectroscopiques concernant les colorants synthétiques techniques présentées par Formánek et Grandmougin dans leur ouvrage "Untersuchung und Nachweis organischer Farbstoffe auf spektroskopischem Wege" et la revue de la spectroscopie des matières colorantes naturelles, qui se trouve dans l'ouvrage de Kayser "Handbuch der Spektroskopie."

L'objectif principal a été celui de procurer un moyen rapide de s'assurer quelles données sont disponibles pour une matière colorante donnée. À cette fin la sélection des colorants a été faite aussi étendue et les références bibliographiques aussi complètes que possible. Il a aussi été mentionné un très grand nombre de données sur la position spectrale des maxima des bandes d'absorption, pour des conditions variées, dans l'ultra-violet, le visible et l'infra-rouge, qui se révèleront ordinairement suffisantes pour ceux qui s'occupent de l'identification des colorants ou de la corrélation entre la couleur et la constitution. Si une définition qualitative ou quantitative plus complète de l'absorption est désirée, celle-ci pourra être obtenue promptement dans bien des cas en consultant les références mentionnées.

Les colorants synthétiques ont été arrangés par classes en douze tables et sont inscrits en listes suivant l'ordre de leurs formules de constitution. Les matières colorantes naturelles ont été disposées dans l'ordre alphabétique dans la Table 13.

Les formules des colorants sont suivies des noms scientifiques des matières colorantes, complétés dans certains cas par les noms d'un usage plus courant, et les nombres C. I. (Colour Index of the Society of Dyers and Colourists). Tous les maxima d'absorption dans les spectres ultra-violet et visible sont exprimés en millimicrons. Les valeurs en italique concernent les bandes principales, et les valeurs entre crochets ont rapport à des bandes relativement insignifiantes. (Plusieurs valeurs comprises entre deux crochets signifient des maxima multiples dans une seule bande.) Les données d'absorption sont suivies de nombres de référence indiquant la source dont elles proviennent; d'autres nombres de référence mentionnés à la suite se rapportent à d'autres sources bibliographiques relatives aux colorants en question qui peuvent présenter par surcroit un certain intérêt. Les références suivies de (q) signifient la disponibilité de données au point de vue plus défini de l'aspect quantitatif de l'absorption.

available for a given dye are meager and difficult to locate, in general, and since any information may be of service, it has not been considered advisable to exclude any material of definite character.

Die folgenden Tafeln bilden eine Ergänzung (1) zu den Tafeln spektroskopischer Werte technischer synthetischer Farbstoffe, die von Formánek und Grandmougin in ihrem Werke "Untersuchung und Nachweis organischer Farbstoffe auf spektroskopischem Wege" beigegeben sind. Sie ergänzen (2) die Zusammenstellung über die Spektroskopie natürlicher Farbstoffe, die Kayser in seinem "Handbuch der Spektroskopie" gegeben hat.

Das Hauptziel war, ein bequemes Mittel für die Feststellung zu schaffen, welche Werte für einen bestimmten färbenden Stoff zu Gebote stehen. Unter diesem Gesichtspunkte geschah die Auswahle der Farbstoffe so umfassend wie möglich und der Nachweis der Literatur möglichst vollständig. Dort wurden zahlreiche Angaben über die spektrale Lage der Maxima von Absorptionsbanden zusammengetragen und zwar für verschiedene Bedingungen: im sichtbaren, Ultraviolett und Infrarot. In der Regel werden sie sich als ausreichend erweisen für diejenigen Forscher, denen an der Identifizierung von Farbstoffen oder an der Beziehung von Farbe und Konstitution gelegen ist. Braucht man eine vollständigere qualitative oder quantitative Definition der Absorption, so ist sie in zahlreichen Fällen bequem zu erhalten, wenn man die gesammelten Literaturangaben einsieht.

Synthetische Farbstoffe sind nach Klassen in zwölf Tafeln angeordnet und in der Reihenfolge ihrer Konstitutionsformeln aufgeführt. Natürliche Farbstoffe sind in alphabetischer Folge in Tafel 13 gesammelt.

Den Formeln der Farbstoffe folgen die wissenschaftlichen Namen der färbenden Stoffe. Zur Ergänzung dienen in einigen Fällen mehr allgemein gebräuchliche Bezeichnungen und die C. I. Nummern (des "Colour Index of the Society of Dyers and Colourists"). Alle Absorptions-Maxima im Ultraviolett und in sichtbaren Spektren sind in Millimikron angegeben. Kursiv (in Schrägschrift) gesetzte Werte beziehen sich auf die Hauptbanden, eingeklammerte Werte beziehen sich auf verhältnismässig unbedeutende Banden. (Das Zusammenklammern verschiedener Werte bedeutet mehrere Maxima in einer einzelnen Bande.) Auf die Absorptionswerte folgen die Nummern-Angaben anderer Literaturstellen für die in Rede stehenden Farbstoffe, die von weiterem Interesse sein können. Angaben, die mit einem (q) versehen sind, kennzeichnen die Brauchbarkeit von Werten für die mehr quantitative Betrachtung der Absorption.

In Fällen, in denen verschiedene Werte aus von einander unabhängigen Quellen zur Verfügung standen, hat der Herausgeber die ihm zuverlässiger erscheinenden Werte aufgenommen. Die Frage der Verlässlichkeit, die für einen grossen Teil des Stoffes gestellt werden kann, ist der Entschiedung des Lesers überlassen. Im allgemeinen sind die für einen bestimmten Farbstoff verfügbaren Werte so dürftig und auch so schwierig festzustellen—während auch der geringste Nachweis schon von Nutzen sein kann—dass es nicht ratsam erschien, irgendwelche Unterlagen bestimmten Charakters fortzulassen.

Dans le cas où des données diverses d'origines différentes ont été disponibles, les valeurs mentionnées sont celles qui ont paru les plus dignes de confiance au rédacteur. La question de la confiance, qui peut être placée dans la plus grande portion de la matière présentée, est laissée à la discrimination du lecteur. Comme les données disponibles pour un colorant donné sont en général peu abondantes et difficiles à trouver et comme chaque information peut être utile, il a été considéré comme judicieux de n'exclure aucune matière présentant un caractère défini.

Le seguenti tabelle sono compilate come complemento delle tabelle di dati spettroscopici sulle sostanze coloranti sintetiche di uso industriale dati da Formánek e Grandmougin nella loro "Untersuchung und Nachweis organischer Farbstoffe auf spektroskopischem Wege" e sulle sostanze coloranti naturali contenute nel "Handbuch der Spektroskopie" di Kayser.

Il principale nostro scopo è stato quello di fornire un modo rapido per stabilire quali sono i dati dei quali si dispone per qualsiasi sostanza colorante. Tenendo presente questo fine si è tenuto conto del maggior numero possibile di sostanze coloranti, e si è riportato nel modo più completo la bibliografia. Abbiamo pure riportato un considerevole numero di dati sopra la posizione dei massimi nelle bande di assorbimento in diverse condizioni, nell'ultra-violetto, nel visibile e nell'infra-rosso, i quali dati potranno bastare per chi si interessa della identificazione dei coloranti o dei rapporti tra colore e costituzione. Se si vuole un quadro più completo, dal punto di vista qualitativo o quantitativo, dell'assorbimento, lo si può ottenere subito in molti casi consultando le citazioni riportate.

I coloranti sintetici sono stati disposti per classi in dodici tavole e ordinati in base alle loro formule di costituzione. Le sostanze coloranti naturali sono state messe in ordine alfabetico nella Tavola 13.

Le formule dei coloranti sono seguite dai nomi scientifici della sostanza colorante completati in alcuni casi con i nomi di uso più comune e con i numeri del C. I. (Colour Index of the Society of Dyers and Colourists). Tutti i massimi di assorbimento nell'ultra-violetto e nello spettro visibile sono riportati in millimicron. I valori in italici si riferiscono alle principali bande e i valori fra parentesi alle bande relativamente insignificanti. (Le parentesi comuni che racchiudono vari valori significano massimi multipli in una stessa banda.) I dati degli assorbimenti sono seguiti da numeri che si riferiscono alla memoria dalle quali sono stati presi insieme con altri numeri di riferimento ad altra letteratura sul colorante in questione, che può essere di ulteriore interesse. Quando una citazione è seguita da (q) significa che si hanno a disposizione dati quantitativi sull'assorbimento.

Nei casi nei quali si sono potuti avere dati di origine indipendente, i valori riportati sono quelli che sono sembrati i più attendibili al compilatore. La questione della fiducia che si può avere nella maggior parte dei dati riprodotti è lasciata al criterio del lettore. Siccome i valori ottenibili per un dato colorante sono in genere rari e difficili a rintracciare e siccome qualsiasi informazione può essere utile, non abbiamo creduto opportuno di escludere nessun dato di carattere definito.

ABBREVIATIONS

AcO = CH_3COO^-
HOAc = CH_3COOH
AmOH = $C_5H_{11}OH$
B. A. A. = Boric acid—acetic anhydride
EtOH = C_2H_5OH
S. B. A. = Sulfuric—boric acid

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Table 1.—Monoazo Dyes

$C_{10}H_8N_4O_2$.—*o*-Nitrobenzeneazopyrrole: 639 in EtOH (76).

m-Nitrobenzeneazopyrrole: 560 in EtOH (76).

p-Nitrobenzeneazopyrrole: 600 in EtOH (76).

$C_{10}H_9N_3$.—Benzeneazopyrrole: 612 in EtOH (76).

$C_{11}H_{10}N_4O_2$.—*p*-Nitrobenzeneazo-*N*-methylpyrrole: 635 in EtOH (76).

$C_{12}H_6Br_4N_2O_2$.—Tetrabromo-*p*-azophenol: 476, 360 in EtOH (with both α- and β-isomers) (543).

$C_{12}H_6N_8O_{12}$.—Hexanitrohydrazobenzene: 314 in $CHCl_3$; 493 in MeOH; 337 with HCl; 500 with NaOEt (224).

$C_{12}H_7Br_2N_3O_3$.—*p*-Nitrobenzeneazo-*m*-dibromophenol: alkali salt, 555 in Me_2CO; 511 in EtOH; 493 in H_2O (643).

$C_{12}H_7Br_3N_2O$.—*sym*.-Tribromobenzeneazophenol: 430, 384 in alk. H_2O (468).

$C_{12}H_8BrN_3O_3$.—*p*-Nitrobenzeneazo-*p*-bromophenol: alkali salt, 550 in Me_2CO; 504 in EtOH; 498 in H_2O (643).

p-Nitrobenzeneazo-*o*-bromophenol: alkali salt, 559 in Me_2CO; 502 in EtOH; 480 in H_2O (643).

$C_{12}H_8ClN_3O_3$.—*p*-Nitrobenzeneazo-*m*-chlorophenol: alkali salt, 556 in Me_2CO; 501 in EtOH; 470 in H_2O (643).

$C_{12}H_8N_4O_4$.—*p*-Dinitroazobenzene: 494 in H_2O (463).

$C_{12}H_9BrN_2O$.—Benzeneazo-*o*-bromophenol: 436, 390 in alk. H_2O (468).

p-Bromobenzeneazophenol: 445, 395 in alk. H_2O (468); *cf.* (595).

$C_{12}H_9ClN_2O$.—Chlorobenzeneazophenol: data on *o*-, *m*- and *p*-isomers (596).

$C_{12}H_9ClN_4$.—Azobenzenediazonium chloride: 340 in EtOH (260).

$C_{12}H_9IN_2$.—*p*-Iodoazobenzene: 340 in EtOH (476, *294* with HCl) (260).

$C_{12}H_9N_3O_3$.—*o*-Nitrobenzeneazophenol: 362, 235 in EtOH; *437*, 240 in alk. H_2O (62); 356 in EtOH (465 with NaOEt) (31); 487, 440 in alk. H_2O (468); *cf.* (596q, 622).

m-Nitrobenzeneazophenol: 350 in EtOH (459 with NaOEt) (31); *358*, 245 in EtOH; *436*, 262 in alk. H_2O (62); 480 in alk. H_2O (471); *cf.* (596q, 622).

p-Nitrobenzeneazophenol; *380*, 257 in EtOH; *478*, 273, (237) in alk. H_2O (62); alkali salt, 556 in Me_2CO; 505 in EtOH; 475 in H_2O (643); *cf.* (31, 468, 501, 521, 595, 596q, 624).

$C_{12}H_9N_3O_4$.—*o*-Nitrobenzeneazoresorcinol: abs. in visible and ultra-violet in neutral and alk. solns. (622).

m-Nitrobenzeneazoresorcinol; abs. in visible and ultra-violet in neutral and alk. solns. (624).

p-Nitrobenzeneazocatechol: abs. in visible and ultra-violet for neutral and alk. solns. (622).

p-Nitrobenzeneazoresorcinol: alkali salt, 605 in Me_2CO; 570 in EtOH; 550 in H_2O (643); *cf.* (501, 624).

p-Nitrobenzeneazohydroquinol: abs. in visible and ultra-violet for neutral and alk. solns. (622).

$C_{12}H_9N_3O_5$.—*p*-Nitrobenzeneazopyrogallol: alkali salt, 528 in Me_2CO (643); *cf.* (623).

p-Nitrobenzeneazophloroglucinol: abs. in visible and ultra-violet for neutral and alk. solns. (623).

$C_{12}H_9N_3O_6S$.—*p*-Nitrobenzeneazosulfocarbolate: alkali salt, 575 in Me_2CO; 514 in EtOH (643); data given in (501) are incorrect.

$C_{12}H_{10}N_2$.—Azobenzene: 463, 312 in H_2O (suspension) (471); 444, (345), *317* in EtOH; *417*, 280 in concd. HCl (59); 440 in H_2SO_4; 589 in fuming acid (diacid salt) (310). In EtOH, 455, 313 (84); (third band at 229) (393). Similar abs. in $CHCl_3$ (210) and in vapor form (532); *cf.* (26, 29, 111, 185q, 201q, 214, 220q, 231q, 385, 413, 516, 534q, 618).

$C_{12}H_{10}N_2O$.—Azoxybenzene: 323 in EtOH and in vapor form (532). Metallic salts (225); *cf.* (533).

o-Hydroxyazobenzene: 441, 390 in alk. H_2O; 480 in acid H_2O (468).

m-Hydroxyazobenzene: 415, 380 in alk. H_2O (468).

p-Hydroxyazobenzene (benzeneazophenol): 340, 315 in H_2O; 433, 395 with alkali; 490, 463 with acid (468); *429*, 268 in alk. H_2O (62); 331 in HCl (618); 465, 248 in H_2SO_4 (210); 360 in EtOH (*456*, 320 with NaOEt); 348 in Et_2O (211); (470), *355*, 235 in EtOH (62). Abs. in 30 organic solvents (12q). Abs. of various derivs. (185q, 220q); *cf.* (26, 111, 225, 469, 471, 475, 544, 595, 596q, 613q, 624).

$C_{12}H_{10}N_2O_2$.—2, 2′-Dihydroxyazobenzene: 490 in alk. H_2O (471).

2, 4-Dihydroxyazobenzene (benzeneazoresorcinol): 483 in alk. H_2O (471); *488*, 450 in H_2SO_4 (196); 408 in EtOH (352); *cf.* (624).

3, 3′-Dihydroxyazobenzene: 500, 475 in alk. H_2O (471).

3, 4-Dihydroxyazobenzene (benzeneazocatechol): 480, 430 in alk. H_2O (468); *cf.* (622).

2, 5-Dihydroxyazobenzene (benzeneazoquinol): abs. of neutral and alk. solns. in visible and ultra-violet (622).

2, 4′-Dihydroxyazobenzene: 490 in alk. H_2O (471).

3, 4′-Dihydroxyazobenzene: 480 in alk. H_2O (471).

4, 4′-Dihydroxyazobenzene: 473 in alk. H_2O, 360 in EtOH (463 with NaOEt) (619).

$C_{12}H_{10}N_2O_3$.—2, 3, 4-Trihydroxyazobenzene: abs. in visible and ultra-violet in neutral and alk. solns. (623).

2, 4, 2′-Trihydroxyazobenzene: 540, 492 in alk. H_2O (471).

2, 4, 4′-Trihydroxyazobenzene: 528, 490 in alk. H_2O (471).

2, 4, 5-Trihydroxyazobenzene: 505, 440, 345 in alk. H_2O (471).

2, 4, 6-Trihydroxyazobenzene: 460, 410 in alk. H_2O (471); *490*, 405 in H_2SO_4 (196); *cf.* (623).

3, 4, 4′-Trihydroxyazobenzene: 470, 535 in H_2O with Na_2CO_3; 470, 440 with $NaHCO_3$ (471).

3, 4, 5-Trihydroxyazobenzene: 515, 495, 420 in alk. H_2O (471).

$C_{12}H_{10}N_2O_3S$.—Azobenzene-*p*-sulfonic acid: 432 in H_2O over pH range 1–12 (613q).

$C_{12}H_{10}N_2O_4$.—2, 2′, 4, 4′-Tetrahydroxyazobenzene: 575, 540, 462 in H_2O with $NaHCO_3$ (471).

2,′ 4, 3′, 4′-Tetrahydroxyazobenzene: 585 in alk. H_2O (471).

3, 3′, 4, 4′-Tetrahydroxyazobenzene: 680 in alk. H_2O (471).

$C_{12}H_{10}N_2O_4S$.—*m*-Sulfobenzeneazophenol: 460, 410 in alk. H_2O (471).

p-Sulfobenzeneazophenol: 440, 400 in alk. H_2O (471); *cf.* (595, 613).

Benzeneazosulfocarbolate: 455 in alk. H_2O (468).

$\mathbf{C_{12}H_{10}N_2O_5S}$.—*p*-Sulfobenzeneazocatechol: 520 with NaOH; 485 with Na_2CO_3 (471).

p-Sulfobenzeneazoresorcinol (C. I. 148): Na salt, 430 in H_2O (271); *cf.* (231q, 420q, 525q).

$\mathbf{C_{12}H_{10}N_2O_6S}$.—*p*-Sulfobenzeneazophloroglucinol: 490 in H_2SO_4 (196).

$\mathbf{C_{12}H_{10}N_4O_2}$.—3′-Nitro-4-aminoazobenzene: 518, 490 in acid H_2O (471).

$\mathbf{C_{12}H_{11}N_3}$.—*m*-Aminoazobenzene: 430 in H_2O (pH 1) (613); (495 in acid H_2O (471)).

p-Aminoazobenzene: 490 in acid H_2O (pH 1) (613); 420 in H_2SO_4 (diacid salt); 556 in fuming acid (triacid salt); *395*, 250 in EtOH (300 with HCl) (310). Abs. of vapor (532); *cf.* (26, 260, 385, 463, 468, 469, 619).

Diazoaminobenzene: 361, 235 in EtOH; abs. of vapor (532).

$\mathbf{C_{12}H_{11}N_3O}$.—Aminoazoxybenzene: 527 in acid H_2O (468).

3-Hydroxy-4′-aminoazobenzene: 490, 470 in acid H_2O; 485, 430 in alk. H_2O (471).

p-Aminobenzeneazophenol: 385 in EtOH; *546*, 354 in dil. HCl; 467 in conc. HCl (diacid salt) (261).

$\mathbf{C_{12}H_{11}N_3O_2}$.—2-Amino-3′, 4-dihydroxyazobenzene: 478 in alk. H_2O; 490, 460 in acid H_2O (471).

5-Amino-2, 4′-dihydroxyazobenzene: 460 in alk. soln. (473).

$\mathbf{C_{12}H_{11}N_3O_3S}$.—4-Sulfo-4′-aminoazobenzene (Aniline Orange): 485 in acid H_2O (pH 1) (613q); 448, (280) in dil. NaOH; 496 in dil. HCl (216).

$\mathbf{C_{12}H_{12}N_2}$.—Hydrazobenzene: 290, *245* in EtOH (413); 310 in $CHCl_3$ (534).

$\mathbf{C_{12}H_{12}N_4}$.—*p*-Diaminoazobenzene: 499 in acid H_2O (463); 603 in very dil. HOAc (monacid salt); 497, 310 in EtOH + 3% HCl (diacid salt); 410 in H_2SO_4 (triacid salt) (261).

Benzeneazo-*m*-phenylenediamine (hydrochloride, C. I. 20): Infra-red abs. (296). Acid salts (497); *cf.* (231q).

$\mathbf{C_{13}H_9N_3O_4}$.—*p*-Nitrobenzeneazosalicylaldehyde: alkali salt, 564 in Me_2CO; 500 in EtOH; 478 in H_2O (643).

p-Nitrobenzeneazo-*p*-hydroxybenzaldehyde: alkali salt, 547 in Me_2CO; 494 in EtOH; 470 in H_2O (643).

$\mathbf{C_{13}H_9N_3O_5}$.—*p*-Nitrobenzeneazosalicylic acid (C. I. 40): 609 in alk. Me_2CO; 555 in alk. EtOH; 514 in alk. H_2O (643); *cf.* (501, 525q, 595).

p-Nitrobenzeneazo-*m*-hydroxybenzoic acid: alkali salt, 583 in Me_2CO; 508 in EtOH; 474 in H_2O (643).

p-Nitrobenzeneazo-*p*-hydroxybenzoic acid: alkali salt, 566 in Me_2CO; 505 in EtOH; 475 in H_2O (643).

$\mathbf{C_{13}H_{10}ClN_3O_2}$.—*p*-Nitrobenzeneazo-2-chloro-5-hydroxytoluene: alkali salt, 580 in Me_2CO; 524 in EtOH; 505 in H_2O (643).

$\mathbf{C_{13}H_{10}N_2O}$.—Benzoylazobenzene: 294 in EtOH (?) (434).

$\mathbf{C_{13}H_{10}N_2O_3}$.—4-Hydroxy-2-carboxyazobenzene: 445, 395 in alk. H_2O (471).

4-Hydroxy-2′-carboxyazobenzene: 435, 385 in alk. H_2O (471).

$\mathbf{C_{13}H_{10}N_2O_3}$.—4-Hydroxy-3-carboxyazobenzene: 452, 402 in alk. H_2O (471).

4-Hydroxy-3′-carboxyazobenzene: 438, 388 in alk. H_2O (471).

4-Hydroxy-4′-carboxyazobenzene: 452, 402 in alk. H_2O (471).

$\mathbf{C_{13}H_{10}N_2O_4}$.—2, 4′-Dihydroxy-5-carboxyazobenzene: 475 in alk. soln. (473).

$\mathbf{C_{13}H_{10}N_4O_4}$.—*p*-Nitrobenzeneazosalicylamide: alkali salt, 525 in Me_2CO; 480 in EtOH (643).

$\mathbf{C_{13}H_{11}N_3O_3}$.—*o*-Nitrobenzeneazo-*o*-cresol: *380*, 238 in EtOH; *457*, 273 in alk. H_2O (62).

o-Nitrobenzeneazo-*m*-cresol: *375*, 240 in EtOH; *445*, 278 in alk. H_2O (62).

o-Nitrobenzeneazo-*p*-cresol: abs. in visible and ultra-violet in neutral and alk. solns. (621).

m-Nitrobenzeneazo-*m*-cresol: *375*, 257 in EtOH; *436*, 273 in alk. H_2O (62).

m-Nitrobenzeneazo-*o*-cresol: *370*, 255 in EtOH; *465*, 276 in alk. H_2O (62).

m-Nitrobenzeneazo-*p*-cresol: abs. in visible and ultra-violet in neutral and alk. solns. (621).

p-Nitrobenzeneazo-*o*-cresol: *391*, 273 in EtOH; *493*, 287 in alk. H_2O (62); alkali salt, 590 in Me_2CO; 530 in EtOH; 490 in H_2O (643); *cf.* (621).

p-Nitrobenzeneazo-*m*-cresol: *398*, 266 in EtOH; *486*, 286 in alk. H_2O (62); 585 in alk. Me_2CO; 520 in alk. EtOH (643); *cf.* (501, 621).

p-Nitrobenzeneazo-*p*-cresol: alkali salt, 590 in Me_2CO: 542 in EtOH; 499 in H_2O (643); *cf.* (94, 501).

$\mathbf{C_{13}H_{11}N_3O_4}$.—*p*-Nitrobenzeneazoguaiacol: alkali salt, 600 in Me_2CO; 540 in EtOH; 510 in H_2O (643); *cf.* (501, 622).

p-Nitrobenzeneazosaligenin: alkali salt, 565 in Me_2CO; 509 in EtOH; 483 in H_2O (643); *cf.* (501).

p-Nitrobenzeneazoorcinol: 539 in alk. Me_2CO (643).

p-Nitrobenzeneazoresorcinol methyl ether; alkali salt, 574 in Me_2CO; 520 in EtOH; 493 in H_2O (643).

p-Nitrobenzeneazohydroquinol methyl ether: abs. in visible and ultra-violet in neutral and alk. solns. (622).

$\mathbf{C_{13}H_{11}N_3O_7S}$.—*p*-Nitrobenzeneazothiocol: alkali salt, 555 in Me_2CO; 536 in EtOH; 510 in H_2O (643); *cf.* (501).

$\mathbf{C_{13}H_{12}N_2O}$.—Benzeneazo-*o*-cresol: (470), *358*, 238 in EtOH; *450*, 273 in alk. H_2O (62); *cf.* (621).

Benzeneazo-*m*-cresol: 352 in EtOH (431 with NaOEt); 481, 328 in HCl (618); (450), *358*, 238 in EtOH; *412*, 270 in alk. H_2O (62); *cf.* (621).

Benzeneazo-*p*-cresol: 316 in EtOH (488, 330 with NaOEt); 492, 406 in HCl (618); *cf.* (624).

Tolueneazophenol: abs. of isomers in visible and ultra-violet in neutral and alk. solns. (621); abs. of derivs. (220q).

$\mathbf{C_{13}H_{12}N_2O_2}$.—Benzeneazoguaiacol: 460 in alk. H_2O (468).

o-Tolueneazoresorcinol: 435 in EtOH (352); *cf.* (621).

m-Tolueneazoresorcinol: abs. in visible and ultra-violet in neutral and alk. solns. (621).

p-Tolueneazoresorcinol: 427 in EtOH (352); *cf.* (621).

p-Methoxybenzeneazophenol: 360 in EtOH (619).

p-Azoxyanisole: 355 in EtOH (533).

$\mathbf{C_{13}H_{12}N_2O_4S}$.—*p*-Sulfobenzeneazo-*o*-cresol: 463 in alk. H_2O (468).

p-Sulfobenzeneazo-*m*-cresol: 475 in alk. H_2O (468).

$\mathbf{C_{13}H_{12}N_2S}$.—Benzeneazothioanisole: 365 in EtOH (160).

$\mathbf{C_{13}H_{12}N_4O_3}$.—*p*-Nitrobenzeneazo-*o*-methylaminophenol: alkali salt, 635 in Me_2CO; 573 in EtOH; 550 in H_2O (643).

$\mathbf{C_{13}H_{13}N_3}$.—Benzeneazo-*o*-toluidine: *505*, 308 in 2*N* HCl; 392 in EtOH (216).

$\mathbf{C_{13}H_{13}N_3O_3S}$.—*p*-Sulfobenzeneazo-*o*-toluidine (*o*-Toluidine Orange): 491 in dil. HCl (613q); 414, (280) in dil. NaOH; 488, (319) in dil. HCl (216).

m-Sulfobenzeneazo-*m*-toluidine (*m*-Toluidine Orange): 483 in dil. acid (613q); 414, (280) in dil. NaOH; 501, (320) in dil. HCl (216).

4-Sulfo-4′-methylaminoazobenzene (Monomethyl Orange): 500 in acid soln. (pH 1); 454 in alk. soln. (pH 12) (613q); 453, (280) in dil. NaOH; 506 in dil. HCl (216).

$\mathbf{C_{13}H_{11}N_3O_5}$.—*p*-Nitrobenzeneazovanillin: alkali salt; 572 in Me_2CO; 525 in EtOH; 509 in H_2O (643).

$\mathbf{C_{14}H_{11}N_3O_4}$.—*p*-Nitrobenzeneazohomosalicylaldehyde: alkali salt, 595 in Me_2CO; 546 in EtOH; 525 in H_2O (643).

$\mathbf{C_{14}H_{11}N_3O_5}$.—*p*-Nitrobenzeneazomethylsalicylate: alkali salt, 530 in Me_2CO; 485 in EtOH; 467 in H_2O (643).

p-Nitrobenzeneazo-*o*-cresotic acid: alkali salt, 535 in Me_2CO; 530 in EtOH; 512 in H_2O (643).

$C_{14}H_{11}N_3O_5$.—*p*-Nitrobenzeneazo-*m*-cresotic acid: alkali salt, 544 in Me_2CO; 525 in EtOH; 508 in H_2O (643).

p-Nitrobenzeneazo-*p*-cresotic acid: alkali salt, 579 in Me_2CO; 535 in EtOH; 515 in H_2O (643).

$C_{14}H_{12}N_2O_2$.—*p*-Acetylbenzeneazophenol: 370 in EtOH; 476 in NaOH soln. (258).

$C_{14}H_{13}N_3O$.—*p*-Acetylaminoazobenzene: 345 in EtOH (619); *cf.* (385).

$C_{14}H_{13}N_3O_2$.—*m*-Acetylamino-*o*-hydroxyazobenzene (385).

$C_{14}H_{13}N_3O_4$.—*p*-Nitrobenzeneazocreosol: alkali salt, 602 in Me_2CO; 545 in EtOH; 512 in H_2O (643).

$C_{14}H_{14}N_2O$.—Benzeneazophenetole: 340 in EtOH; *474*, 331 in HCl (618).

o-Tolueneazocresol: abs. of cresol isomers in visible and ultraviolet in neutral and alk. solns. (620).

m-Tolueneazocresol: abs. of cresol isomers in visible and ultraviolet in neutral and alk. solns. (620).

p-Tolueneazocresol: abs. of cresol isomers in visible and ultraviolet in neutral and alk. solns. (620). *p*-Cresol isomer: 327 in EtOH (481, 334 with NaOEt); *505*, 427 in HCl (618).

$C_{14}H_{14}N_2O_2$.—*o*, *o′*-Azoanisole: 490 in HOAc-HCl soln. (54q).

p, *p′*-Azoanisole: 500 in HOAc-HCl soln. (54q).

p-Ethoxybenzeneazophenol: 447, 390 in alk. H_2O (468).

$C_{14}H_{14}N_2O_4S$.—2, 6-Dimethyl-4-hydroxy-4′-sulfoazobenzene: influence of pH (613q).

$C_{14}H_{14}N_2S_2$.—*o*, *o′*-Azophenylmethylsulfide: 620 in HOAc-HCl soln. (54q).

p, *p′*-Azophenylmethylsulfide: 577 in HOAc-HCl soln. (54q).

$C_{14}H_{14}N_3O_3$.—*p*-Nitrobenzeneazo-2-hydroxy-1, 3-dimethylbenzene: alkali salt, 610 in Me_2CO; 558 in EtOH; 517 in H_2O (643).

p-Nitrobenzeneazo-2-hydroxy-1, 4-dimethylbenzene: alkali salt, 599 in Me_2CO; 544 in EtOH; 510 in H_2O (643).

p-Nitrobenzeneazo-4-hydroxy-1, 2-dimethylbenzene: alkali salt, 600 in Me_2CO; 540 in EtOH; 510 in H_2O (643).

p-Nitrobenzeneazo-4-hydroxy-1, 3-dimethylbenzene: alkali salt, 605 in Me_2CO; 553 in EtOH; 513 in H_2O (643).

$C_{14}H_{14}N_4O_2$.—*m*-Nitrobenzeneazodimethylaniline: 467 in EtOH (31).

p-Nitrobenzeneazodimethylaniline: 483, 277 in EtOH (31).

$C_{14}H_{14}N_4O_3$.—*p*-Nitrobenzeneazo-*m*-dimethylaminophenol: alkali salt, 596 in Me_2CO; 564 in EtOH; 530 in H_2O (643).

$C_{14}H_{15}N_3$.—*p*-Dimethylaminoazobenzene (C. I. 19): 508 in acid soln. (pH 1); 450 in alk. soln. (pH 13) (613q); 545, 507 in 3% HCl; 420 in H_2SO_4 (diacid salt); 607 in fuming acid (triacid salt); 410 in EtOH; 550, 511, 300 in EtOH + 3% HCl (310); 405, 375 in H_2O; 490, 460 with alkali; 543, 508 with acid (469); *cf.* (26, 111, 210, 214, 218, 423q, 468, 475, 619).

$C_{14}H_{15}N_3O$.—*p*-Dimethylaminobenzeneazophenol: 413 in EtOH; *550*, 341 in dil. HCl; *477*, 314 in HCl (diacid salt) (261).

p-Dimethylaminoazoxybenzene: 545 in acid H_2O (471).

2-Dimethylamino-4-hydroxyazobenzene: 486, 463 in alk. H_2O (471).

4-Dimethylamino-2-hydroxyazobenzene: 492, 463 in alk. H_2O; 503, 473 in acid H_2O (471).

$C_{14}H_{15}N_3O_3S$.—*p*-Sulfobenzeneazodimethylaniline (Na salt, C. I. 142, Methyl Orange): 506 in acid soln. (pH 1), 472 in alk. soln. (pH 13) (613q); 442 in EtOH; *481*, 281 in H_2O; *465*, 280 in *N* NaOH; 508, (333), 283 in dil. HCl (469); *cf.* (208, 231, 269, 473, 525, 583q, 612, 647).

m-Sulfobenzeneazodimethylaniline: 535, 490 in acid H_2O (471).

o-Sulfobenzeneazodimethylaniline: 510 in acid soln. (pH 1); 435 in alk. soln. (pH 13); 516 in 6*N* HCl (613q).

p-Sulfobenzeneazoethylaniline: 498 in acid soln. (pH 1); 442 in alk. soln. (pH 12) (613q); 493 in dil. HCl; 453, (280) in dil. NaOH (216).

2, 5-Dimethyl-4-amino-4′-sulfoazobenzene: 490 in acid H_2O (613q).

3, 5-Dimethyl-4-amino-4′-sulfoazobenzene: 500 in acid H_2O (613q).

$C_{14}H_{16}N_2O_2$.—Benzeneazodimethyldihydroresorcinol: 394, 246 in EtOH (472, *349*, 283 with NaOEt) (380).

$C_{14}H_{16}N_4$.—Anilineazodimethylaniline: *513*, 306, 256 in EtOH with 0.1*N* HCl (214); *cf.* (473).

$C_{15}H_{10}N_2O_3$.—Benzeneazocarbonylcoumaranone: *417*, 250 in EtOH (*368*, 286 with NaOEt) (abs. of acetyl deriv. also described) (434).

$C_{15}H_{11}N_3O$.—Quinolineazophenol: 380 in EtOH (159).

5-Benzeneazo-8-hydroxyquinoline: 376 in EtOH; 518, 256 in HCl (159).

$C_{15}H_{12}N_4O$.—5-*p*-Aminobenzeneazo-8-hydroxyquinoline: 412 in EtOH (159).

$C_{15}H_{13}N_3O_5$.—*p*-Nitrobenzeneazoethylsalicylate: alkali salt, 531 in Me_2CO; 490 in EtOH; 465 in H_2O (643).

$C_{15}H_{15}N_3O_2$.—2-Carboxy-4-dimethylaminoazobenzene: 549, 503 (471).

3-Carboxy-4-dimethylaminoazobenzene: 531, 497 (471).

2′-Carboxy-4-dimethylaminoazobenzene (Methyl Red, C. I. 211): 517 in pH 1 soln.; 530 in pH 4.5 soln.; 447 in pH 13 soln. (613q); 530 in alk. soln. (58q) (double band, 548, 514 (469)); *cf.* (433, 471, 612q).

3′-Carboxy-4-dimethylaminoazobenzene: 538, 503 (471).

4′-Carboxy-4-dimethylaminoazobenzene: 512 in acid soln. (pH 1); 463 in alk. soln. (pH 13) (613q); 539, 495 (471).

$C_{15}H_{16}N_2O$.—Benzeneazo-*m*-cresetole: 348 in EtOH (*479*, 331 with NaOEt) (618).

Benzeneazo-*p*-cresetole: 313 in EtOH; 500, 410 in HCl (618).

$C_{15}H_{17}N_3$.—Benzeneazodimethyl-*o*-toluidine: 347 in EtOH; 493, 250 in 2*N* HCl (216).

$C_{15}H_{17}N_3O$.—2-Methoxy-4-dimethylaminoazobenzene: 575, 532 in acid H_2O (471).

4′-Methoxy-4-dimethylaminoazobenzene: 412 in EtOH; *510*, 351 in dil. HCl; *473*, 323 in HCl (diacid salt) (261); 549, 350, 200 in 0.1*N* HCl (214).

$C_{15}H_{17}N_3O_3S$.—*p*-Sulfobenzeneazodimethyl-*o*-toluidine: 374 in EtOH; 447, *311* in HCl (216).

$C_{15}H_{17}N_3O_4S$.—*m*-Methoxymethyl orange: 510, 480 (473).

$C_{15}H_{18}N_2O_2$.—Benzeneazodimethyldihydroresorcinol methyl ether: *379*, 244 in EtOH (380).

$C_{15}H_{18}ClN_3$.—Azobenzenetrimethylammonium chloride: 448, *312* (216).

$C_{15}H_{18}IN_3$.—Azobenzenetrimethylammonium iodide: 437, *314* in EtOH; 498, (314) in EtOH + 1% HCl; 428 in H_2SO_4; (500), 435 in HCl (26); *cf.* (210, 260).

$C_{16}H_{10}BrN_3O_3$.—4′-Nitrobenzeneazo-2-bromo-1-naphthol: 608 in alk. EtOH (473).

$C_{16}H_{11}BrN_2O$.—*p*-Bromobenzeneazo-*α*-naphthol: 470 in EtOH; K salt, 476 in EtOH (595).

$C_{16}H_{11}N_3O_3$.—*o*-Nitrobenzeneazo-*α*-naphthol: 476 in EtOH (540 with NaOEt) (31).

m-Nitrobenzeneazo-*β*-naphthol (*m*-Nitroaniline Orange, C. I. 38): 557.6, 524.1 in H_2SO_4 (190).

p-Nitrobenzeneazo-*α*-naphthol: alkali salt, 630 in Me_2CO; 590 in EtOH; 568 in H_2O (643); (602), 576, (552) in H_2O; (623), 598, (572) in EtOH (468); *cf.* (501).

p-Nitrobenzeneazo-*β*-naphthol (*p*-Nitroaniline Red, C. I. 44): 578.3, 541.3 in H_2SO_4 (352); alkali salt, 587 in Me_2CO; 555 in EtOH (643); *cf.* (501).

$C_{16}H_{12}N_2O$.—Benzeneazo-*α*-naphthol: 496 in alk. H_2O, (468); 469, 405 in EtOH (29); 490, 406, 275 in EtOH (352); 585 in H_2SO_4 (196); *cf.* (595).

$C_{16}H_{12}N_2O$.—Benzeneazo-β-naphthol (Sudan I, C. I. 24): 514, 311 in EtOH; 311 in H_2SO_4 (352); *563*, 517 in H_2SO_4 (196); *cf.* (423q, 619).

$C_{16}H_{12}N_2O_2$.—Benzeneazo-1, 5-dihydroxynaphthalene: 540 in alk. EtOH (174).

Benzeneazo-2, 7-dihydroxynaphthalene: *545*, 498 in H_2SO_4 (196).

p-Hydroxybenzeneazo-α-naphthol: 490 in alk. EtOH (174).

p-Hydroxybenzeneazo-β-naphthol: 610, *490* in alk. EtOH (174).

$C_{16}H_{12}N_2O_3$.—*p*-Hydroxybenzeneazo-1, 3-dihydroxynaphthalene: 490 in alk. EtOH (174).

p-Hydroxybenzeneazo-1, 5-dihydroxynaphthalene: 550 in alk. EtOH (174).

p-Tolueneazocarbonylcoumaranone: 431, 253 in EtOH (369, 288 with NaOEt) (434).

$C_{16}H_{12}N_2O_4S$.—Benzeneazo-α-naphthol-2-sulfonic acid: Na salt, (424q).

Benzeneazo-α-naphthol-4-sulfonic acid: *547*, 500 in H_2SO_4 (196).

Benzeneazo-β-naphthol-5-sulfonic acid: 525, 493 in H_2SO_4 (196).

Benzeneazo-β-naphthol-6-sulfonic acid: 526.5, *495* in H_2SO_4 (196); Na salt, *493*, 315 in H_2O (352).

Benzeneazo-β-naphthol-7-sulfonic acid: 534 in H_2SO_4 (196).

Benzeneazo-β-naphthol-8-sulfonic acid: 522, *495* in H_2SO_4 (196).

p-Sulfobenzeneazo-α-naphthol (Orange I, C. I. 150): *476*, 267, 232 in H_2O (179q); *cf.* (231q, 420q, 422q, 468, 519q, 595).

p-Sulfobenzeneazo-β-naphthol (Orange II, C. I. 151): 490 in H_2O (271); *cf.* (231q).

$C_{16}H_{12}N_2O_5S$.—*m*-Sulfo-*o*-hydroxybenzeneazo-β-naphthol (Na salt, C. I. 169), Pontachrome Violet S. W.: 548 in H_2O (concd.), 515 (dil.) (269).

$C_{16}H_{12}N_2O_7S_2$.—Benzeneazo-α-naphthol-4, 8-disulfonic acid: *557*, 500 in H_2SO_4 (196).

Benzeneazo-β-naphthol-3, 6-disulfonic acid (Na salt, Orange R, C. I. 28): 528, 496 in H_2SO_4 (196); *500*, 321 in H_2O (352); *cf.* (231q).

Benzeneazo-β-naphthol-6, 8-disulfonic acid (Na salt, Orange G, C. I. 27): 503, 487 in H_2SO_4 (196); *491*, 320 in H_2O (352); *cf.* (162, 271).

p-Sulfobenzeneazo-α-naphthol-2-sulfonic acid: Na salt (424q).

$C_{16}H_{12}N_2O_8S_2$.—Benzeneazo-1, 8-dihydroxynaphthalene-3, 6-disulfonic acid (Na salt, C. I. 29, Chromotrop 2R): 510 in H_2O (271).

$C_{16}H_{12}N_2O_8S_2$.—*p*-Hydroxybenzeneazo-α-naphthol-3, 6-disulfonic acid: 560, 494 (473).

$C_{16}H_{12}N_2O_9S_2$.—1-Hydroxy-3, 6-sulfonaphthaleneazoresorcinol: 491 in alk. soln.; 545, 491 in acid soln. (473).

$C_{16}H_{12}N_4O_2$.—2-(4′-Nitrobenzeneazomethylene)-1, 2-dihydroquinoline: 545 in EtOH; 527 in H_2SO_4; hydrochloride, 460 in EtOH; data given for isomeric phenylhydrazone (341).

$C_{16}H_{12}N_4O_9S_2$.—2-*p*-Nitrobenzeneazo-1-amino-8-naphthol-3, 6-disulfonic acid: 522 in 1% HCl; 556 in 1% NaOH; 584 in 10% NaOH; 535 in H_2O (60q).

$C_{16}H_{13}N_3$.—Benzeneazo-α-naphthylamine: 293 in H_2SO_4 (352).

Benzeneazo-β-naphthylamine (Oil Yellow A. B., C. I. 22): 585 in H_2SO_4 (196); 453, *322* in H_2SO_4; 474, 306 in EtOH (352); *cf.* (423q).

$C_{16}H_{13}N_3O$.—*p*-Hydroxybenzeneazo-β-naphthylamine: 565 in alk. EtOH (174).

$C_{16}H_{13}N_3O_3S$.—Benzeneazo-β-naphthylamine-5-sulfonic acid: 543, 498 in H_2SO_4 (196).

Benzeneazo-β-naphthylamine-6-sulfonic acid: *545*, 495 in H_2SO_4 (196).

Benzeneazo-β-naphthylamine-7-sulfonic acid: 545, 495 in H_2SO_4 (196).

$C_{16}H_{13}N_3O_4S$.—*o*-Aminosulfobenzeneazo-β-naphthol: 567.5, 537 (123).

m-Aminosulfobenzeneazo-β-naphthol: 556.3, 526 (123).

p-Aminosulfobenzeneazo-β-naphthol: 563, 533.3 (123).

$C_{16}H_{13}N_3O_6S$.—1-Amino-4-sulfo-2-naphtholazoresorcinol: 640, 590.5, 550 in alk. soln.; 583.5, 543, 513.5 in acid soln. (123).

1-Amino-6-sulfo-2-naphtholazoresorcinol: 560, 510, 472 in H_2O; 625, 582, 540 with NH_4OH (123).

1-Amino-7-sulfo-2-naphtholazoresorcinol: 566, 520, 481 in H_2O; 633, 588, 546 with NH_4OH (123).

1-Amino-8-sulfo-2-naphtholazoresorcinol: 547, 514 in H_2O; 610, 568, 530 with NH_4OH (123).

2-Amino-3-sulfo-1-naphtholazoresorcinol: 560, 483 in H_2O; 630, 541.5, 502.5 with NH_4OH (123).

2-Amino-4-sulfo-1-naphtholazoresorcinol: 561, 518, 478 in H_2O; 528 with NH_4OH (123).

2-Amino-5-sulfo-1-naphtholazoresorcinol: 574, 529, 476 in H_2O; 586, 541 with NH_4OH (123).

$C_{16}H_{13}N_3O_6S_2$.—Benzeneazo-β-naphthylamine-3, 6-disulfonic acid: 539, 495 in H_2SO_4 (196).

$C_{16}H_{13}N_3O_7S$.—2-Amino-4-sulfo-1, 8-dihydroxynaphthaleneazoresorcinol: 518 in alk. soln. (123).

$C_{16}H_{13}N_3O_7S_2$.—Benzeneazo-1, 8-aminonaphthol-3, 6-disulfonic acid: 541 in NaOH; 529, 494 in HCl; 545, 502 in HOAc (473); 495 in 10% NaOH; 530 in H_2O (60).

2, 4-Disulfo-1-aminobenzeneazo-β-naphthol: 507.5, *483* in H_2O; *560*, 528.5 in H_2SO_4; 505, *479.5* in EtOH (123).

2, 5-Disulfo-1-aminobenzeneazo-β-naphthol: 509.5, *478* in H_2O; *562*, 538 in H_2SO_4; 502, 479.5 in EtOH (123).

$C_{16}H_{13}N_3O_9S_2$.—1-Amino-3, 6-disulfo-2-naphtholazoresorcinol: 566.5, 526, 486.5 in H_2O; 635, 586.5, 550 with NH_4OH (123).

1-Amino-6, 8-disulfo-2-naphtholazoresorcinol: 543, 508.2 in H_2O; 611.5, 536, 497 with NH_4OH (123).

2-Amino-3, 6-disulfo-1-naphtholazoresorcinol: 569, 537.5, 502 in H_2O; 635, 582.5 with NH_4OH (123).

2-Amino-3, 8-disulfo-1-naphtholazoresorcinol: 564, 480.5 in H_2O; 637.5, 588 with NH_4OH (123).

2-Amino-4, 8-disulfo-1-naphtholazoresorcinol: 560, 523, 483 in H_2O; 629, 560 with NH_4OH (123).

$C_{16}H_{13}N_3O_{10}S_2$.—2-Amino-3, 6-disulfo-1, 8-dihydroxynaphthaleneazoresorcinol: 564.5, 537 in alk. soln.; 591.5, 549.5 in acid soln. (123).

$C_{16}H_{13}N_3O_{12}S_3$.—1-Amino-3, 6, 8-trisulfo-2-naphtholazoresorcinol: 555, 521 in H_2O; 626.5, 578, 541.5 with NH_4OH (123).

$C_{16}H_{15}BrN_2O$.—*p*-Bromobenzene-1-azo-1′, 2′, 3′, 4′-tetrahydro-4-naphthol: K salt, 476 in EtOH (595).

$C_{16}H_{15}N_3O_3$.—*p*-Nitrobenzene-1-azo-1′, 2′, 3′, 4′-tetrahydro-4-naphthol: K salt, 581 in EtOH (595).

$C_{16}H_{15}N_3O_4$.—*p*-Nitrobenzeneazoeugenol: alkali salt, 610 in Me_2CO; 556 in EtOH; 535 in H_2O (643); *cf.* (501).

$C_{16}H_{16}N_2O$.—Benzeneazotetrahydro-α-naphthol: 470, 430 in alk. H_2O; 471 in EtOH (595).

$C_{16}H_{17}N_3O_3$.—*p*-Nitrobenzeneazocarvacrol: alkali salt, 606 in Me_2CO; 545 in EtOH; 511 in H_2O (643); *cf.* (501).

p-Nitrobenzeneazothymol: alkali salt, 610 in Me_2CO; 559 in EtOH; 515 in H_2O (643); *cf.* (501).

$C_{16}H_{18}ClN_3O_3S$.—2-Chloro-4-diethylamino-4′-sulfoazobenzene: 510 in acid soln. (pH 1); 470 in alk. soln. (pH 12) (613q).

$C_{16}H_{18}N_2O$.—Benzeneazothymol: 455, 410 in alk. H_2O (468).

p-Tolueneazo-*p*-cresetole: 325 in EtOH; *495*, 420 in HCl (618).

$C_{16}H_{18}N_2O_2$.—Azophenetole: 384 in EtOH (431 with NaOEt) (619).

$C_{16}H_{18}N_2O_3$.—*p*-Azoxyphenetole: 360 in EtOH (533).

$C_{16}H_{18}N_2O_5S$.—*o*-Methyl-*m*-isopropyl-*p*-sulfobenzeneazoresorcinol: Na salt, 440 in H_2O (271).

$C_{16}H_{18}N_4O$.—4-Acetylamino-4′-dimethylaminoazobenzene: 540 (473).

$C_{16}H_{19}N_3O$.—4-Ethoxy-4′-dimethylaminoazobenzene: 548 (473).

$C_{16}H_{19}N_3O_3S$.—4-Diethylamino-4′-sulfoazobenzene (Ethyl Orange): 510 in acid soln. (pH 1); 470 in alk. soln. (pH 13) (613q).

$C_{16}H_{19}N_3O_5S$.—2, 2′-Dimethoxy methyl orange: 537, 495 (473).

$C_{16}H_{20}N_4$.—Tetramethyl-*p*-diaminoazobenzene: 450 in EtOH; 692, (514), 450 in dil. HOAc; 530, 497 in 3% HCl (diacid salt); (498), 410 in H_2SO_4 (triacid salt) (310); *cf.* (475).

$C_{17}H_{11}N_3O_5$.—*p*-Nitrobenzeneazo-*n*-butylsalicylate: alkali salt, 556 in Me_2CO; 496 in EtOH; 480 in H_2O (643).

p-Nitro-α-naphthaleneazosalicylic acid: K salt, 541 in EtOH (595).

$C_{17}H_{12}N_2O_6S$.—*o*-Carboxybenzeneazo-α-naphthol-2-sulfonic acid: Na salt (424q).

$C_{17}H_{13}N_3O_3$.—*o*-Nitro-*p*-tolueneazo-β-naphthol (Toluidine Red, C. I. 69): 569.4, 533.2 in H_2SO_4 (190); 561 in gelatin (114).

$C_{17}H_{14}N_2O$.—*o*-Tolueneazo-α-naphthol: *406*, 275 in EtOH (352).

o-Tolueneazo-β-naphthol: *515*, 313 in EtOH; 313 in H_2SO_4 (352).

p-Tolueneazo-α-naphthol: 402 in EtOH; 300 in H_2SO_4 (352).

p-Tolueneazo-β-naphthol: *495*, 312 in EtOH (352).

$C_{17}H_{14}N_2O_4S$.—*o*-Tolueneazo-β-naphthol-6-sulfonic acid: Na salt, *496*, 316 in H_2O; 311 in H_2SO_4 (352).

p-Tolueneazo-β-naphthol-6-sulfonic acid: Na salt, *498*, 316 in H_2O (352).

o-Tolueneazo-α-naphthol-2-sulfonic acid: Na salt (424q).

p-Tolueneazo-α-naphthol-2-sulfonic acid: Na salt (424q).

$C_{17}H_{14}N_2O_5S$.—2-Anisoleazo-α-naphthol-6-sulfonic acid (Na salt, Anisole Red): 522 in gelatin (114).

$C_{17}H_{14}N_2O_7S_2$.—*o*-Tolueneazo-β-naphthol-3, 6-disulfonic acid: Na salt, *503*, 323 in H_2O (352).

o-Tolueneazo-β-naphthol-6, 8-disulfonic acid: Na salt, *491*, 324 in H_2O; 320 in H_2SO_4 (352).

p-Tolueneazo-β-naphthol-3, 6-disulfonic acid: Na salt, *500*, 322 in H_2O (352).

p-Tolueneazo-β-naphthol-6, 8-disulfonic acid: Na salt, *497*, 323 in H_2O (352).

$C_{17}H_{14}N_4O_2$.—1-Methyl-2-(4′-nitrobenzeneazomethylene)-1, 2-dihydroquinoline: hydrochloride, 527 in H_2SO_4 (343).

$C_{17}H_{15}N_3$.—*o*-Tolueneazo-α-naphthylamine: 298 in H_2SO_4 (352).

o-Tolueneazo-β-naphthylamine (Oil Yellow OB, C. I. 61): 474, 306 in EtOH; 455, 323 in H_2SO_4 (352); *cf.* (220q).

p-Tolueneazo-β-naphthylamine: 473, 305 in EtOH; 323 in H_2SO_4 (352).

$C_{17}H_{16}N_4O_2$.—2-(4′-Nitrobenzeneazomethylene)-3, 3-dimethylindoline: hydrochloride, 469 in HOAc (347).

$C_{17}H_{17}N_3$.—2-(Benzeneazomethylene)-3, 3-dimethylindoline: hydrochloride, 465; base, 435 (347).

$C_{17}H_{19}N_3O_2$.—2-Carboxy-4′-diethylaminoazobenzene: 512 in pH 1 soln.; 522 in pH 4 soln.; 499 in pH 12 soln. (613q).

4-Dimethylamino-4′-ethylcarboxyazobenzene: *444*, 275 in EtOH (214).

$C_{18}H_{12}N_4O$.—Quinolineazo-8-hydroxyquinoline: 403 in EtOH (159).

$C_{18}H_{14}N_2O$.—Diphenylazophenol: 451 in alk. H_2O (468).

$C_{18}H_{14}N_2O_2$.—*p*-Hydroxydiphenylazophenol; monobasic salt, 492 ($NaHCO_3$); dibasic salt, 470 (NaOH) (463).

Benzeneazo-α-naphthyl acetate: 376 in EtOH (619).

Benzeneazo-β-naphthyl acetate: 472, 282 in EtOH (619).

p-Acetylbenzeneazo-α-naphthol: 467, 315 in EtOH; 526, 300 in NaOH (258).

p-Acetylbenzeneazo-β-naphthol: 476, 318 in EtOH; 513, 286 in NaOH (258).

$C_{18}H_{14}N_2O_6S$.—*o*-Methylcarboxybenzeneazo-α-naphthol-2-sulfonic acid: Na salt (424q).

$C_{18}H_{15}N_3O_3S$.—4-Phenylamino-4′-sulfoazobenzene (Na salt, C. I. 143): 527 in pH 1 soln.; 456 in pH 12 soln. (613q).

$C_{18}H_{15}N_3O_8S_2$.—Benzeneazo-8-acetylamino-1-naphthol-3, 6-disulfonic acid (Na salt, C. I. 31): Kiton Red G (22).

$C_{18}H_{16}N_2O$.—Benzeneazo-α-naphthol ethyl ether: 400 in EtOH (619).

$C_{18}H_{17}N_3$.—Benzeneazodimethyl-α-naphthylamine: 570, 525 in acid H_2O (471).

$C_{18}H_{17}N_3O_3S$.—4-Sulfonaphthaleneazodimethylaniline: (473).

$C_{18}H_{18}N_4O_3$.—2-(4′-Nitro-2′-methoxybenzeneazomethylene)-3, 3-dimethylindoline: hydrochloride, 484 in HOAc (347).

$C_{19}H_{14}N_2O_2$.—*p*-Benzoylbenzeneazophenol: 481, 333 in EtOH (?) (471); 370 in EtOH; 476 in NaOH (258).

$C_{19}H_{14}N_4O_2$.—*p*-Nitrobenzylideneaminoazobenzene: 383 in EtOH (521).

$C_{19}H_{15}N_3$.—Benzylidineaminoazobenzene: 383 in EtOH (521).

$C_{19}H_{15}N_3O$.—*p*-Hydroxybenzylidineaminoazobenzene: 375 in EtOH (521).

$C_{19}H_{17}N_3O_3S$.—*p*-Sulfobenzeneazobenzylaminobenzene: 448, (280) in dil. NaOH; 496 in dil. HCl (216); 560 in pH 1 soln. (613q).

$C_{19}H_{18}N_2O_7S_2$.—Pseudocumeneazo-β-naphthol-3, 6-disulfonic acid (Na salt, C. I. 80): *504*, 330 in H_2O (179q); *cf.* (422q).

$C_{19}H_{19}N_3O$.—2-(4′-Acetylbenzeneazomethylene)-3, 3-dimethylindoline: hydrobromide, 456 in EtOH (347).

$C_{19}H_{19}N_3O_4S$.—*p*-Sulfo-*o*-methoxybenzeneazodimethyl-α-napthylamine: 580, 525, 500 in acid H_2O (595).

$C_{19}H_{20}N_4O_2$.—2-(4′-Nitrobenzeneazomethylene)-3, 3-diethylindoline: hydrochloride, 472 in HOAc (347).

$C_{20}H_{13}BrN_2O$.—*p*-Bromobenzene-1-azo-4-anthrol: 503 in EtOH; K salt, 588 in EtOH (595).

$C_{20}H_{13}N_3O_3$.—*p*-Nitrobenzeneazoanthrol: 460 in EtOH (595).

p-Nitrobenzene-1-azo-4-anthrol: 482 in EtOH; K salt, 650 in EtOH (595).

3′-Nitro-4-hydroxyazonaphthalene: 557 in H_2O (471).

$C_{20}H_{14}N_2O$.—Benzeneazoanthrol: 466 in EtOH; K salt, 580 in EtOH (595).

Benzene-1-azo-4-anthrol: 499 in EtOH; K salt, 549 in EtOH (595).

α-Naphthaleneazo-β-naphthol (Autol Red RL, C. I. 82): 628, 585.8 in H_2SO_4 (190).

β-Naphthaleneazo-β-naphthol: 483 in EtOH (85).

β, β′-Azoxynaphthalene: 337, 282, 266 in EtOH (?) [550 after exposure to light] (85).

$C_{20}H_{14}N_2O_4S$.—*p*-Sulfobenzene-1-azo-4-anthrol: 503 in EtOH; K salt, 571 in EtOH (595).

α-Naphthaleneazo-α-naphthol-2-sulfonic acid: Na salt (424q).

β-Naphthaleneazo-α-naphthol-2-sulfonic acid: Na salt (424q).

4-Sulfo-α-naphthaleneazo-α-naphthol (Na salt, C. I. 175): (231).

4-Sulfo-α-naphthaleneazo-β-naphthol (Na salt, Fast Red A.S., C. I. 176): 500 in H_2O (concd.); 505 (dil.) (269); *cf.* (231, 390, 391, 516).

$C_{20}H_{14}N_2O_7S_2$.—α-Naphthaleneazo-β-naphthol-3, 6-disulfonic acid (Na salt, Bordeaux B, C. I. 88): 510 in H_2O (concd.); 515 (dil.) (269); *cf.* (421q, 516q, 588).

α-Naphthaleneazo-β-naphthol-6, 8-disulfonic acid (Na salt, Crystal Scarlet, C. I. 89); *508*, 329.5 in H_2O (391q); *cf.* (388q, 518q).

4-Sulfo-α-naphthaleneazo-α-naphthol-2-sulfonic acid: Na salt (424q).

4-Sulfo-α-naphthaleneazo-α-naphthol-4-sulfonic acid (Na salt, C. I. 179): "Azorubin," infra-red abs. (511); Pontacyl Ruby G, 505 in H_2O (concd.); 512 (dil.) (269); Chromotrope FB, 555.9, *519.5* in dil. HOAc; 569.5 in H_2SO_4; Chrome Lake, *620.7*, 575.7, 537.5 in 90% HOAc + HCl; *614.7*, 568.2, 530.3 in H_2SO_4 (190).

$C_{20}H_{14}N_2O_8S_2$.—α-Naphthaleneazo-1, 8-dihydroxynaphthalene-3, 6-disulfonic acid (Na salt, C. I. 90): 533 in $0.1N$ HCl; 519 in $0.1N$ NaOH; 535 in H_2O (pH 6.75) (11q).

$C_{20}H_{14}N_2O_{10}S_3$.—α-Naphthaleneazo-α-naphthol-3, 6, 8-trisulfonic acid: Na salt, 534 in $0.1N$ HCl; 514 in $0.1N$ NaOH; 535 in pH 6.75 soln. (11q).

4-Sulfo-α-naphthaleneazo-β-naphthol-3, 6-disulfonic acid (Na salt, Amaranth, C. I. 184): *522*, 331 in H_2O (179q); *cf.* (422q).

4-Sulfo-α-naphthaleneazo-β-naphthol-6, 8-disulfonic acid (Na salt, C. I. 185): Cochineal Red A, *515*, 500 on wool (522).

$C_{20}H_{15}N_3$.—α-naphthaleneazo-α-naphthylamine: (231q).

β-Naphthaleneazo-β-naphthylamine: (231q).

$C_{20}H_{15}N_3O_4S$.—4-Sulfo-1-naphthylamineazo-β-naphthol: Na salt, 500 in H_2O; 629, 587.5 in H_2SO_4 (123).

5-Sulfo-1-naphthylamineazo-β-naphthol: Na salt, 499 in H_2O; 608.5, 568 in H_2SO_4 (123).

6-Sulfo-1-naphthylamineazo-β-naphthol: Na salt, 499 in H_2O; 607.5, 568.5 in H_2SO_4 (123).

7-Sulfo-1-naphthylamineazo-β-naphthol: Na salt, 500 in H_2O; 572 in H_2SO_4 (123).

1-Sulfo-2-naphthylamineazo-β-naphthol; Na salt, 505.5 in H_2O; 589.5, 552.5 in H_2SO_4 (123).

5-Sulfo-2-naphthylamineazo-β-naphthol: Na salt, 492.5 in H_2O; 576, 541.5 in H_2SO_4 (123).

6-Sulfo-2-naphthylamineazo-β-naphthol: Na salt, 494 in H_2O; 579.5, 543.5 in H_2SO_4 (123).

7-Sulfo-2-naphthylamineazo-β-naphthol: Na salt, 493 in H_2O; 580, 543 in H_2SO_4 (123).

8-Sulfo-2-naphthylamineazo-β-naphthol: Na salt, 494.5 in H_2O; 581, 544.5 in H_2SO_4 (123).

$C_{20}H_{15}N_3O_7S_2$.—α-Naphthaleneazo-8-amino-α-naphthol-3, 6 disulfonic acid: Na salt, 544 in $0.1N$ HCl; 545 in $0.1N$ NaOH; 548 in pH 6.75 soln. (11).

3, 6-Disulfo-1-naphthylamineazo-β-naphthol: Na salt, 498.5 in H_2O; 604.5, 568 in H_2SO_4 (123).

3, 8-Disulfo-1-naphthylamineazo-β-naphthol: Na salt, 492 in H_2O; 578.5, 542 in H_2SO_4 (123).

4, 7-Disulfo-1-naphthylamineazo-β-naphthol: Na salt, 498.5 in H_2O; 617, 575 in H_2SO_4 (123).

4, 8-Disulfo-1-naphthylamineazo-β-naphthol: Na salt, 491 in H_2O; 540 in H_2SO_4 (123).

3, 6-Disulfo-2-naphthylamineazo-β-naphthol: Na salt, 493.5 in H_2O (123).

4, 7-Disulfo-2-naphthylamineazo-β-naphthol: Na salt, 495.5 in H_2O; 582, 542.5 in H_2SO_4 (123).

4, 8-Disulfo-2-naphthylamineazo-β-naphthol: Na salt, 492 in H_2O; 581.5, 544.5 in H_2SO_4 (123).

5, 7-Disulfo-2-naphthylamineazo-β-naphthol: Na salt, 490.5 in H_2O; 580, 543 in H_2SO_4 (123).

6, 8-Disulfo-2-naphthylamineazo-β-naphthol: Na salt, 494.5 in H_2O; 583.5, 546 in H_2SO_4 (123).

$C_{20}H_{15}N_3O_{10}S_3$.—5-Sulfo-1-naphthylamineazo-β-naphthol-3, 6-disulfonic acid: Na salt, 594.5, 555 in H_2SO_4 (123).

6-Sulfo-1-naphthylamineazo-β-naphthol-3, 6-disulfonic acid: Na salt, 572, 537.5 in H_2SO_4 (123).

$C_{20}H_{15}N_3O_{13}S_4$.—3, 6-Disulfo-2-naphthylamineazo-β-naphthol-3, 6-disulfonic acid: Na salt, 495 in H_2O; 583, 547 in H_2SO_4 (123).

$C_{20}H_{16}N_2O_2$.—*p*-Benzoylbenzeneazo-*p*-cresol: 327 in EtOH; 513, 341 in NaOH (258); *cf.* (618).

$C_{20}H_{16}N_4O_5S$.—4-Sulfo-1, 5-diamino-2-naphtholazo-α-naphthol: Na salt, 521.5 in alk. soln.; 518 in acid soln. (123).

$C_{20}H_{16}N_4O_{11}S_3$.—3-Sulfo-2, 5-diamino-1-naphtholazo-β-naphthol-3, 6-disulfonic acid: Na salt, 496.5 in H_2SO_4 (123).

$C_{20}H_{17}N_3O$.—*p*-Methoxybenzylideneaminoazobenzene: 327 in EtOH; 513, 341 in NaOH (521).

$C_{20}H_{18}N_4O_9S_2$.—*p*-Acetylaminobenzeneazo-8-acetylamino-α-naphthol-3, 6-disulfonic acid (Na salt, C. I. 57): Pontacyl Carmine 6B, 514 in H_2O (concd.); 525 (dil.) (269).

$C_{20}H_{20}N_2O$.—*p*-Cymeneazo-β-naphthol: 532 in H_2SO_4 (677).

$C_{20}H_{20}N_2O_3S$.—*p*-Cymeneazo-α-naphthalene-4-sulfonic acid: Na salt, 460 in H_2O (677).

$C_{20}H_{26}N_2O_4S$.—*o*-Methyl-*m*-isopropyl-*p*-sulfobenzeneazo-β-naphthol: Na salt, 495 in H_2O (271).

$C_{20}H_{20}N_2O_7S_2$.—*o*-Methyl-*m*-isopropylbenzeneazo-β-naphthol-6, 8-disulfonic acid: Na salt, 492 in H_2O (271).

$C_{20}H_{20}N_2O_8S_2$.—*o*-Methyl-*m*-isopropylbenzeneazo-1, 8-dihydroxynaphthalene-3, 6-disulfonic acid: Na salt, 520 in H_2O (271).

$C_{20}H_{20}N_2O_{10}S_3$.—*o*-Methyl-*m*-isopropyl-*p*-sulfobenzeneazo-β-naphthol-3, 6-disulfonic acid: Na salt, 498 in H_2O (677). (The 6, 8-disulfo isomer in H_2O, 485 (677).)

$C_{20}H_{20}N_2O_{11}S_3$.—*o*-Methyl-*m*-isopropyl-*p*-sulfobenzeneazo-1, 8-dihydroxynaphthalene-3, 6-disulfonic acid: Na salt, 525 in H_2O (271).

$C_{20}H_{21}N_3$.—*p*-Cymeneazo-β-naphthylamine: 570 in H_2SO_4 (677).

$C_{20}H_{26}N_2$.—Azocymene: 465 in H_2SO_4 (677).

$C_{21}H_{13}N_3O_5$.—*p*-Nitronaphthalene-1-azo-4-naphthol-3-carboxylic acid: 470 in EtOH; K salt, 606 in EtOH (595).

$C_{22}H_{17}N_3O_3S$.—4-Diphenylazo-α-naphthylamine-4-sulfonic acid: 575 in dil. HCl (468).

$C_{22}H_{18}N_4O_5S$.—8-Sulfo-4-amino-1-phenylnaphthylamineazo-resorcinol: 561.5 with excess H_2SO_4 (123).

$C_{22}H_{19}N_3O_7S_2$.—3, 6-Disulfo-8-hydroxy-α-naphthaleneazoethyl-α-naphthylamine (Na salt, C. I. 307): Pontacyl Sulfon Violet R, 530 in H_2O (concd.); 550 (dil.) (269).

$C_{22}H_{20}N_2O_2$.—*p*-Benzoylbenzeneazo-*p*-cresetole: 326 in EtOH (618).

$C_{23}H_{16}N_2O_2$.—*p*-Benzoylbenzeneazo-α-naphthol: 461, 330 in EtOH; 535, 300 in NaOH (258).

p-Benzoylbenzeneazo-β-naphthol: 486, 320 in EtOH; 513, 283 in NaOH (258).

$C_{23}H_{16}N_4O_4$.—*p*-Nitrobenzeneazo-β-hydroxynaphthoic acid anilide (Fast Red GG): 570 in H_2SO_4 (677).

$C_{23}H_{22}N_4O_3$.—Phenyl-(*p*-dimethylaminobenzeneazobenzoylamino)-acetic acid: *461*, 375 (306), 274 in EtOH (abs. of *d*, *l*, and *dl* forms identical) (64q).

$C_{24}H_{16}ClN_3O_7S_3$.—Benzenylaminothiocresolazo-8-chloro-α-naphthol-3, 6-disulfonic acid (Na salt, C. I. 128): Diamine Rose BD on cotton and silk (627).

$C_{25}H_{19}N_3O_4$.—β-Naphthol deriv. of diazotized phenyl- (*p*-aminobenzoylamino)- acetic acid: *486*, (381), 314, (271) in H_2O; 516, *443* with excess alkali; 553, *522* with excess acid (abs. of *d*, *l* and *dl* forms identical) (63q).

$C_{26}H_{17}N_3O_6$.—*p*-Nitrobenzeneazophenolphthalein: alkali salt, 568 in Me_2CO; 508 in EtOH; 495 in H_2O (643); *cf.* (501).

$C_{26}H_{21}N_5O_8S_2$.—3-Sulfo-2, 5-diamino-α-naphtholazophenyl-β-naphthylamine-5-hydroxy-7-sulfonic acid: 493.8 in dil. H_2SO_4 (123).

$C_{27}H_{20}N_4O_9S_2$.—8-Benzoylamino-2-amino-3, 5-disulfo-α-naphtholazo-β-naphthol: 525, 493 in H_2SO_4 (123).

Aminobenzoyl-H-acid-azo-β-naphthol: 608, 578 in H_2SO_4 (123).

Azo dyes derived from substituted pyrroles: (33, 378, 399, 408, 409).

p-Nitrobenzeneazocephaeline: 610 in alk. Me_2CO; 550 in alk. EtOH; 525 in alk. H_2O (502).

p-Nitrobenzeneazoemetamine: 627.5 in alk. Me_2CO; 590 in alk. EtOH; 570 in alk. H_2O (502).

TABLE 2.—POLYAZO DYES

$C_{18}H_{13}N_5O_3$.—*p*-Nitrobenzeneazobenzeneazophenol: 395 in EtOH; Na salt, 546 in EtOH (521).

$C_{18}H_{14}N_4O$.—Benzeneazobenzeneazophenol: 435 (111); 497 in alk. H_2O (463).

$C_{18}H_{14}N_4O_2$.—Phenolazobenzeneazophenol: disodium salt, 515 in H_2O (463).

$C_{18}H_{18}N_8$.—Benzene-*m*-disazo-*bis*-*m*-phenylenediamine (hydrochloride, Bismarck Brown Y, C. I. 331): infra-red abs. (296); 460 on cotton (627); *cf.* (231).

$C_{20}H_{19}N_5$.—Benzeneazobenzeneazodimethylaniline: 509 (111).

$C_{22}H_{15}N_7O_{11}S_2$.—2-*p*-Nitrobenzeneazo-1-amino-8-naphthol-3, 6-disulfo-7-azo-*p*-nitrobenzene: Na salt, 612 in H_2O (60a).

$C_{22}H_{16}N_4O$.—Benzeneazobenzeneazo-*α*-naphthol: *655*, 625 in H_2SO_4 (196).

Benzeneazobenzeneazo-*β*-naphthol (Sudan III, C. I. 248): *640.9*, 589.8 in H_2SO_4 (190); *cf.* (196).

$C_{22}H_{16}N_4O_3S$.—*p*-Sulfobenzeneazobenzeneazo-*α*-naphthalene: Na salt, 507 in H_2O; 516 in 0.02*N* HCl; 663 in H_2SO_4 (436).

$C_{22}H_{16}N_4O_4S$.—Benzeneazobenzeneazo-*α*-naphthol-4-sulfonic acid (Na salt, C. I. 249): *627*, 575 in H_2SO_4 (196).

Benzeneazobenzeneazo-*β*-naphthol-6-sulfonic acid: *610*, 580 in H_2SO_4 (196).

Benzeneazobenzeneazo-*β*-naphthol-8-sulfonic acid: 598, 572 in H_2SO_4 (196).

$C_{22}H_{16}N_4O_6S_2$.—*p*-Sulfobenzeneazo-*o*-sulfobenzeneazo-*α*-naphthalene: Na salt, 524 in H_2O; 542 in alk. H_2O; 519 in 0.02*N* HCl; 643 in H_2SO_4 (436).

p-Sulfobenzeneazobenzeneazo-*α*-naphthalene-7-sulfonic acid: Na salt, 532 in H_2O (520 with alkali); 496 in 0.02*N* HCl; 657 in H_2SO_4 (436).

$C_{22}H_{16}N_4O_7S_2$.—Benzeneazobenzeneazo-*α*-naphthol-4, 8-disulfonic acid (Na salt, C. I. 251): *630*, 575 in H_2SO_4 (196).

Benzeneazobenzeneazo-*β*-naphthol-3, 6-disulfonic acid (Na salt, C. I. 253): *616*, 573 in H_2SO_4 (196).

Benzeneazobenzeneazo-*β*-naphthol-6, 8-disulfonic acid (Na salt, C. I. 252): *592*, 550 in H_2SO_4 (196). Brilliant Croceine M, 545 on silk (627).

p-Sulfobenzeneazo-*o*-sulfobenzeneazo-*β*-naphthol (Na salt, Biebrich Scarlet, C. I. 280): (231).

$C_{22}H_{16}N_4O_9S_3$.—*p*-Sulfobenzeneazo-*o*-sulfobenzeneazo-*α*-naphthalene-7-sulfonic acid: Na salt, 539 in H_2O; 530 in 0.02*N* HCl; 638 in H_2SO_4 (436).

$C_{22}H_{16}N_4O_{10}S_3$.—Benzeneazobenzeneazo-*α*-naphthol-3, 6, 8-trisulfonic acid: *620*, 573 in H_2SO_4 (196).

Benzeneazobenzeneazo-*β*-naphthol-3, 6, 8-trisulfonic acid: 600, 555 in H_2SO_4 (196).

p-Sulfobenzeneazobenzeneazo-*α*-naphthol-4, 8-disulfonic acid: 642 in H_2SO_4 (196).

p-Sulfobenzeneazobenzeneazo-*β*-naphthol-3, 6-disulfonic acid: *607*, 575 in H_2SO_4 (196).

p-Sulfobenzeneazobenzeneazo-*β*-naphthol-6, 8-disulfonic acid: 587 in H_2SO_4 (196).

p-Sulfobenzeneazo-*o*-sulfobenzeneazo-*α*-naphthol-4-sulfonic acid: *688*, 596 in H_2SO_4 (196).

p-Sulfobenzeneazo-*o*-sulfobenzeneazo-*β*-naphthol-8-sulfonic acid: 620 in H_2SO_4 (196).

$C_{22}H_{16}N_4O_{13}S_4$.—*p*-Sulfobenzeneazo-*o*-sulfobenzeneazo-*α*-naphthol-4, 8-disulfonic acid: *631*, 584 in H_2SO_4 (196).

p-Sulfobenzeneazo-*o*-sulfobenzeneazo-*β*-naphthol-3, 6-disulfonic acid: *630*, 575 in H_2SO_4 (196).

p-Sulfobenzeneazo-*o*-sulfobenzeneazo-*β*-naphthol-6, 8-disulfonic acid: 589 in H_2SO_4 (196).

$C_{22}H_{16}N_4O_{16}S_5$.—*p*-Sulfobenzeneazo-*o*-sulfobenzeneazo-*α*-naphthol-3, 6, 8-trisulfonic acid: *629*, 582 in H_2SO_4 (196).

p-Sulfobenzeneazo-*o*-sulfobenzeneazo-*β*-naphthol-3, 6, 8-trisulfonic acid: *607*, 580 in H_2SO_4 (196).

$C_{22}H_{16}N_6O_9S_2$.—*p*-Nitrobenzeneazo-3, 6-disulfo-8-amino-*α*-naphtholazobenzene (Na salt, C. I. 246): Agalma Black 10B, 620 in H_2O (12a); *cf.* (60a); 600 in H_2O (concd.); 620 (dil.) (269).

$C_{22}H_{24}N_6$.—4, 4′-Benzenedisazodimethylaniline: (570), 544, 510 (473).

$C_{24}H_{18}N_4O_2$.—Diphenyldisazo-*bis*-phenol: monosodium salt, 496 ($NaHCO_3$); disodium salt, 370 (NaOH) (463).

5, 5′-*Bis*-benzeneazo-2, 2′-diphenol: 344 in EtOH (?) (544).

$C_{24}H_{18}N_4O_8S_2$.—Diphenyldisazo-*bis*-*p*-sulfophenol: 475 in alk. H_2O (468).

$C_{24}H_{18}N_6O$.—Benzeneazobenzeneazobenzeneazophenol: 436 (111).

$C_{24}H_{20}N_4O$.—*o*-Tolueneazo-*o*-tolueneazo-*β*-naphthol (Sudan IV, C. I. 258): *657.4*, 605.5 in H_2SO_4 (190); *cf.* (516).

$C_{24}H_{20}N_4O_4S$.—*o*-Tolueneazo-*o*-tolueneazo-*α*-naphthol-4-sulfonic acid: 629, 589 in H_2SO_4 (196).

o-Tolueneazo-*o*-tolueneazo-*β*-naphthol-6-sulfonic acid: *630*, 589 in H_2SO_4 (196).

o-Tolueneazo-*o*-tolueneazo-*β*-naphthol-8-sulfonic acid: *620*, 580 in H_2SO_4 (196).

$C_{24}H_{20}N_4O_5S$.—*m*-Sulfobenzeneazo-*p*-methylanisoleazo-*α*-naphthol: Na salt, 506 in H_2O; 503 in 0.02*N* HCl; 592 in 0.02*N* NaOH; 530 in 85% EtOH; 587 in 80% HCOOH (436).

m-Sulfobenzeneazo-*p*-methylanisoleazo-*β*-naphthol: Na salt, 506 in H_2O; 502 in 0.02*N* HCl; 497 in 0.02*N* NaOH; (566), 540 in 85% EtOH; *661*, 597 in 80% HCOOH (436).

p-Sulfobenzeneazo-*p*-methylanisoleazo-*α*-naphthol: Na salt, 513 in H_2O; 512 in 0.02*N* HCl; 596 in 0.02*N* NaOH; 530 in 85% EtOH; *631*, 586 in 80% HCOOH (436).

p-Sulfobenzeneazo-*p*-methylanisoleazo-*β*-naphthol: Na salt, 515 in H_2O; 511 in 0.02*N* HCl; 507 in 0.02*N* NaOH; (566), 545 in 85% EtOH; *633*, 610 in 80% HCOOH (436).

$C_{24}H_{20}N_4O_7S_2$.—*o*-Tolueneazo-*o*-tolueneazo-*α*-naphthol-4, 8-disulfonic acid: *630*, 575 in H_2SO_4 (196).

o-Tolueneazo-*o*-tolueneazo-*β*-naphthol-3, 6-disulfonic acid: *635*, 580 in H_2SO_4 (196).

p-Sulfo-*o*-tolueneazo-*o*-tolueneazo-*α*-naphthol-4-sulfonic acid: *647*, 589 in H_2SO_4 (196).

p-Sulfo-*o*-tolueneazo-*o*-tolueneazo-*β*-naphthol-6-sulfonic acid: *650*, 589 in H_2SO_4 (196).

p-Sulfo-*o*-tolueneazo-*o*-tolueneazo-*β*-naphthol-8-sulfonic acid: *630*, 585 in H_2SO_4 (196).

o-Tolueneazo-*o*-tolueneazo-*β*-naphthol-6,8-disulfonic acid: *675*, 580 in H_2SO_4 (196).

C_{24}**$H_{20}N_4O_8S_2$.**—*m*-Sulfobenzeneazo-*p*-methylanisoleazo-*α*-naphthol-4-sulfonic acid: Na salt, 591, 531 in H_2O; 604, *524* in 0.02*N* HCl; 555 in 0.02*N* NaOH; 583, 538 in 85% EtOH; *675*, 585, 542 in 80% HCOOH (436).

p-Sulfobenzeneazo-*p*-methylanisoleazo-*α*-naphthol-4-sulfonic acid: Na salt, 594, *533* in H_2O; 601, *525* in 0.02*N* HCl; 586, *549* in 0.02*N* NaOH; 586, 549 in 85% EtOH; *676*, 588, 547 in 80% HCOOH (436).

m-Sulfobenzeneazo-*p*-methylanisoleazo-*α*-naphthol-5-sulfonic acid: Na salt, 608, *545* in H_2O; 616, *537* in 0.02*N* HCl; 587, 546 in 85% EtOH; 556 in 0.02*N* NaOH; *674*, 602, 554 in 80% HCOOH (436).

p-Sulfobenzeneazo-*p*-methylanisoleazo-*α*-naphthol-5-sulfonic acid: Na salt, 604, *546* in H_2O; 612, *538* in 0.02*N* HCl; 598, *560* in 0.02*N* NaOH; 585, 546 in 85% EtOH; *677*, 606, (553) in 80% HCOOH (436).

m-Sulfobenzeneazo-*p*-methylanisoleazo-*α*-naphthol-7-sulfonic acid: Na salt, 522 in H_2O; 518 in 0.02*N* HCl; 576 in 0.02*N* NaOH; 523 in 85% EtOH; *629*, 586 in 80% HCOOH (436).

$C_{24}H_{20}N_4O_8S_2$.—*p*-Sulfobenzeneazo-*p*-methylanisoleazo-*α*-naphthol-7-sulfonic acid: Na salt, 522 in H_2O; 518 in 0.02*N* HCl; 578 in 0.02*N* NaOH; 531 in 85% EtOH; *636*, 587 in 80% HCOOH (436).

m-Sulfobenzeneazo-*p*-methylanisoleazo-*α*-naphthol-8-sulfonic acid: Na salt, 528 in H_2O; 523 in 0.02*N* HCl; 635 in 0.02*N* NaOH; *626*, 582 in 80% HCOOH (436).

p-Sulfobenzeneazo-*p*-methylanisoleazo-*α*-naphthol-8-sulfonic acid: Na salt, 535 in H_2O; 528 in 0.02*N* HCl; 635 in 0.02*N* NaOH; *631*, 586 in 80% HCOOH (436).

m-Sulfobenzeneazo-*p*-methylanisoleazo-*β*-naphthol-6-sulfonic acid: Na salt, 625 in H_2O; 617 in 0.02*N* HCl; 523 in 0.02*N* NaOH; 573, 541 in 85% EtOH; 660, 563 in 80% HCOOH (436).

p-Sulfobenzeneazo-*p*-methylanisoleazo-*β*-naphthol-6-sulfonic acid: Na salt, 525 in H_2O; 522 in 0.02*N* HCl; 528 in 0.02*N* NaOH; 573, 544 in 85% EtOH; 666, 592, 564 in 80% HCOOH (436).

m-Sulfobenzeneazo-*p*-methylanisoleazo-*β*-naphthol-8-sulfonic acid: Na salt, 535 in H_2O; 533 in 0.02*N* HCl; 526 in 0.02*N* NaOH; 558, 533 in 85% EtOH; *651*, 598 in 80% HCOOH (436).

p-Sulfobenzeneazo-*p*-methylanisoleazo-*β*-naphthol-8-sulfonic acid: Na salt, 539 in H_2O; 535 in 0.02*N* HCl; 527 in 0.02*N* NaOH; 563, 537 in 85% EtOH; *656*, 609 in 80% HCOOH (436).

$C_{24}H_{20}N_4O_{10}S_3$.—*o*-Tolueneazo-*o*-tolueneazo-*α*-naphthol-3, 6, 8-trisulfonic acid: *640*, 592 in H_2SO_4 (196).

p-Sulfo-*o*-tolueneazo-*o*-tolueneazo-*α*-naphthol-4, 8-disulfonic acid: *630*, 575 in H_2SO_4 (196).

p-Sulfo-*o*-tolueneazo-*o*-tolueneazo-*β*-naphthol-3, 6-disulfonic acid: *630*, 580 in H_2SO_4 (196).

$C_{24}H_{20}N_4O_{11}S_3$.—*m*-Sulfobenzeneazo-*p*-methylanisoleazo-*α*-naphthol-3, 6-disulfonic acid: Na salt, 585, *549* in H_2O; 550 in 0.02*N* HCl; 532 in 0.02*N* NaOH; *573*, 539 in 85% EtOH; *664*, 601 in 80% HCOOH (436).

p-Sulfobenzeneazo-*p*-methylanisoleazo-*α*-naphthol-3, 6-disulfonic acid: Na salt, 580, *551* in H_2O; 586, *548* in 0.02*N* HCl; 554 in 0.02*N* NaOH; *579*, 538 in 85% EtOH; *667*, 602 in 80% HCOOH (436).

m-Sulfobenzeneazo-*p*-methylanisoleazo-*α*-naphthol-3, 8-disulfonic acid: Na salt, 574, *551* in H_2O; 545 in 0.02*N* HCl; 555 in 0.02*N* NaOH; *569*, 539 in 85% EtOH; *657*, 606 in 80% HCOOH (436).

p-Sulfobenzeneazo-*p*-methylanisoleazo-*α*-naphthol-3, 8-disulfonic acid: Na salt, 573, 554 in H_2O; 552 in 0.02*N* HCl; 553 in 0.02*N* NaOH; *574*, 542 in 85% EtOH; *663*, 612 in 80% HCOOH (436).

m-Sulfobenzeneazo-*p*-methylanisoleazo-*β*-naphthol-3, 6-disulfonic acid: Na salt, 588, *543* in H_2O; 595, 542 in 0.02*N* HCl; 548 in 0.02*N* NaOH; 573, 549 in 85% EtOH; 664, 553 in 80% HCOOH (436).

p-Sulfobenzeneazo-*p*-methylanisoleazo-*β*-naphthol-3, 6-disulfonic acid: Na salt, 590, *543* in H_2O; 596, *541* in 0.02*N* HCl; 549 in 0.02*N* NaOH; 573, 550 in 85% EtOH; 669, 594, 558 in 80% HCOOH (436).

m-Sulfobenzeneazo-*p*-methylanisoleazo-*β*-naphthol-6, 8-disulfonic acid: Na salt, 577, 537 in H_2O; 582, 534 in 0.02*N* HCl; 575, 539 in 0.02*N* NaOH; 567, 537 in 85% EtOH; 654 in 80% HCOOH (436).

p-Sulfobenzeneazo-*p*-methylanisoleazo-*β*-naphthol-6, 8-disulfonic acid: Na salt, 574, 540 in H_2O; 597, 537 in 0.02*N* HCl; 575, 541 in 0.02*N* NaOH; 566, 537 in 85% EtOH; *658*, 580 in 80% HCOOH (436).

2, 4-Disulfobenzeneazo-*p*-methylanisoleazo-*α*-naphthol-4-sulfonic acid: Na salt, 594, *547* in H_2O; 600, *544* in 0.02*N* HCl; (598), *564* in 0.02*N* NaOH; 584, 542 in 85% EtOH; *687*, 588, 547 in 80% HCOOH (436).

$C_{24}H_{20}N_4O_{12}S_3$.—*m*-Sulfobenzeneazo-*p*-methylanisoleazo-1, 8-dihydroxynaphthalene-3, 6-disulfonic acid: Na salt, 602, *560* in H_2O; 610, *564* in 0.02*N* HCl; 596 in 0.02*N* NaOH; 603, 560 in 85% EtOH; *685*, 606, 561 in 80% HCOOH (436).

p-Sulfobenzeneazo-*p*-methylanisoleazo-1, 8-dihydroxynaphthalene-3, 6-disulfonic acid: Na salt, 600, *562* in H_2O; 602, 561 in 0.02*N* HCl; 599 in 0.02*N* NaOH; 604, 559 in 85% EtOH; *688*, 614, 567 in 80% HCOOH.(436).

$C_{24}H_{20}N_4O_{13}S_4$.—*p*-Sulfo-*o*-tolueneazo-*o*-tolueneazo-*α*-naphthol-3, 6, 8-trisulfonic acid: 650 in H_2SO_4 (196).

p-Sulfo-*o*-tolueneazo-*o*-tolueneazo-*β*-naphthol-3, 6, 8-trisulfonic acid; *630*, 585 in H_2SO_4 (196).

$C_{24}H_{20}N_4O_{14}S_4$.—*m*-Sulfobenzeneazo-*p*-methylanisoleazo-*α*-naphthol-3, 6, 8-trisulfonic acid: Na salt (580), 558 in H_2O; (582), 561 in 0.02*N* HCl; 570 in 0.02*N* NaOH; 581 in 85% EtOH; *663*, 608 in 80% HCOOH (436).

p-Sulfobenzeneazo-*p*-methylanisoleazo-*α*-naphthol-3, 6, 8-trisulfonic acid: Na salt, 566 in H_2O; (583), 559 in 0.02*N* HCl; 579, 559 in 0.02*N* NaOH; *584*, 545 in 85% EtOH; *669*, 613 in 80% HCOOH (436).

m-Sulfobenzeneazo-*p*-methylanisoleazo-*β*-naphthol-3, 6, 8-trisulfonic acid: Na salt, 593, *545* in H_2O; 594, *542* in 0.02*N* HCl; 547 in 0.02*N* NaOH; 576, 548 in 85% EtOH; *665*, 557 in 80% HCOOH (436).

p-Sulfobenzeneazo-*p*-methylanisoleazo-*β*-naphthol-3, 6, 8-trisulfonic acid: Na salt, 592, *545* in H_2O; 598, *543* in 0.02*N* HCl; 548 in 0.02*N* NaOH; 578, 550 in 85% EtOH; 673 in 80% HCOOH (436).

2, 4-Disulfobenzeneazo-*p*-methylanisoleazo-*α*-naphthol-3, 8-disulfonic acid: Na salt, 573, 558 in H_2O; 576, 552 in 0.02*N* HCl; 565 in 0.02*N* NaOH; 575, 537 in 85% EtOH; 674 in 80% HCOOH (436).

$C_{24}H_{20}N_4O_{15}S_4$.—2, 4-Disulfobenzeneazo-*p*-methylanisoleazo-1, 8-dihydroxynaphthalene-3, 6-disulfonic acid: Na salt, 603, 571 in H_2O; 598, 564 in 0.02*N* HCl; 602 in 0.02*N* NaOH; 606, 563 in 85% EtOH; 692, 613 in 80% HCOOH (436).

$C_{24}H_{20}N_4O_{17}S_5$.—2, 4-Disulfobenzeneazo-*p*-methylanisoleazo-*α*-naphthol-3, 6, 8-trisulfonic acid: Ba salt, 577, 566 in H_2O; 565 in 0.02*N* HCl; 576 in 0.02*N* NaOH; 583, 547 in 85% EtOH; *678*, 618 in 80% HCOOH (436).

$C_{24}H_{21}N_5O_8S_2$.—*m*-Sulfobenzeneazo-*p*-methylanisoleazo-6-amino-*α*-naphthol-3-sulfonic acid: Na salt, 592, *533* in H_2O; 525 in 0.02*N* HCl; 587, *532* in 0.02*N* NaOH; 558, 534 in 85% EtOH; 657 in 80% HCOOH (436).

p-Sulfobenzeneazo-*p*-methylanisoleazo-6-amino-*α*-naphthol-3-sulfonic acid: Na salt, 585, *536* in H_2O; 498 in 0.02*N* HCl; 591, 535 in 0.02*N* NaOH; 554, 533 in 80% EtOH; *662*, 600, 559 in 80% HCOOH (436).

$C_{24}H_{21}N_5O_{11}S_3$.—*m*-Sulfobenzeneazo-*p*-methylanisoleazo-8, amino-*α*-naphthol-3, 6-disulfonic acid: Na salt, 593 in H_2O; 605-571 in 0.02*N* HCl; 587 in 0.02*N* NaOH; 607, 563 in 85% EtOH (436).

p-Sulfobenzeneazo-*p*-methylanisoleazo-8-amino-*α*-naphthol-3, 6-disulfonic acid: Na salt, 603, 575 in H_2O; 603, 569 in 0.02*N* HCl; 593 in 0.02*N* NaOH; 607, 567 in 85% EtOH (436).

2, 4-Disulfobenzeneazo-*p*-methylanisoleazo-6-amino-*α*-naphthol-3-sulfonic acid: Na salt, 575, *550* in H_2O; 591, *542* in 0.02*N* NaOH; 565, 539 in 85% EtOH; 676 in 80% HCOOH (436).

$C_{24}H_{21}N_5O_{14}S_4$.—2, 4-Disulfobenzeneazo-*p*-methylanisoleazo-8-amino-*α*-naphthol-3, 6-disulfonic acid: Na salt, 619, 590 in H_2O; 559, 573 in 0.02*N* HCl; 605 in 0.02*N* NaOH; 612, 573 in 85 % EtOH (436).

$C_{24}H_{30}N_4O_5$.—*p*-Nitrobenzeneazocapsaicin: alkali salt, 593 in Me_2CO; 550 in EtOH; 510 in H_2O (643).

$C_{25}H_{22}N_4O_8S_2$.—4-Sulfo-2-methylbenzeneazo-*p*-methylanisoleazo-*α*-naphthol-4-sulfonic acid: Na salt, (593), 530 in H_2O; (604), 524 in 0.02*N* HCl; 552 in 0.02*N* NaOH; 583, 542 in 85% EtOH (436).

$C_{25}H_{22}N_4O_{11}S_3$.—4-Sulfo-2-methylbenzeneazo-*p*-methylanisoleazo-*α*-naphthol-3, 8-disulfonic acid: Na salt, 576, 551 in H_2O; 545 in 0.02*N* HCl; 552 in 0.02*N* NaOH; 572, 538 in 85% EtOH; 667, 578, 552 in 80% HCOOH (436).

$C_{25}H_{22}N_4O_{12}S_3$.—4-Sulfo-2-methylbenzeneazo-*p*-methylanisoleazo-1, 8-dihydroxynaphthalene-3, 6-disulfonic acid: Na salt, 599, 563 in H_2O; 604, 562 in 0.02*N* HCl; 597 in 0.02*N* NaOH; 602, 561 in 85% EtOH; 554, 513 in 80% HCOOH (436).

$C_{25}H_{23}N_5O_8S_2$.—4-Sulfo-2-methylbenzeneazo-*p*-methylanisoleazo-6-amino-*α*-naphthol-3-sulfonic acid: Na salt (592), 533 in H_2O; 510 in 0.02*N* HCl; 588, 533 in 0.02*N* NaOH; 558, 533 in 85% EtOH (436).

$C_{25}H_{23}N_5O_{11}S_3$.—4-Sulfo-2-methylbenzeneazo-*p*-methylanisoleazo-8-amino-*α*-naphthol-3, 6-disulfonic acid: Na salt, 602, 582 in H_2O; 607, 568 in 0.02*N* HCl; 587 in 0.02*N* NaOH; 607, 567 in 85% EtOH (436).

$C_{26}H_{22}N_4O_2$.—5, 5′-*Bis*-*p*-tolueneazo-2, 2′-diphenol: 350 in EtOH (544).

$C_{26}H_{23}N_7$.—Benzeneazobenzeneazobenzeneazodimethylaniline: 513 (111).

$C_{27}H_{20}N_6O_7$.—Diphenylurea-*p*, *p*′-disazo-*bis*-salicylic acid (Na salt, C. I. 346): Cotton Yellow G (600).

$C_{28}H_{22}N_4O_{11}S_3$.—6-Sulfo-*β*-naphthaleneazo-*p*-methylanisoleazo-*β*-naphthol-3, 6-disulfonic acid: Na salt, 543 in H_2O; 539 in 0.02*N* HCl; 537 in 0.02*N* NaOH; 576, 546 in 85% EtOH; 692 in 80% HCOOH (436).

7-Sulfo-*α*-naphthaleneazo-*p*-methylanisoleazo-*β*-naphthol-3, 6-disulfonic acid: Na salt, 552 in H_2O; 548 in 0.02*N* HCl; 553 in 0.02*N* NaOH; 580, 556 in 85% EtOH (436).

$C_{28}H_{22}N_4O_{14}S_4$.—3, 6-Disulfo-*α*-naphthaleneazo-*p*-methylanisoleazo-*β*-naphthol-3, 6-disulfonic acid: Na salt, 553 in H_2O; (602), 553 in 0.02*N* HCl; (587), 551 in 0.02*N* NaOH; 586, 557 in EtOH (436).

3, 6-Disulfo-*β*-naphthaleneazo-*p*-methylanisoleazo-*β*-naphthol-3, 6-disulfonic acid: Na salt, 552 in H_2O; 558 in 0.02*N* HCl; 540 in 0.02*N* NaOH; 576, 500 in 85% EtOH; 705 in 80% HCOOH (436).

$C_{28}H_{22}N_4O_{17}S_5$.—3, 6, 8-Trisulfo-*β*-naphthaleneazo-*p*-methylanisoleazo-*β*-naphthol-3, 6-disulfonic acid: Na salt, 573, 556 in H_2O; 584, 556 in 0.02*N* HCl; 548 in 0.02*N* NaOH; 580, 555 in 85% EtOH; 707 in 80% HCOOH (436).

$C_{28}H_{23}N_5O_8S_2$.—6-Sulfo-*β*-naphthaleneazo-*p*-methylanisoleazo-6-amino-*α*-naphthol-3-sulfonic acid: Na salt, 592 in H_2O; 530 in 0.02*N* HCl; (598), 547 in 0.02*N* NaOH; 568, 546 in 85% EtOH (436).

7-Sulfo-*α*-naphthaleneazo-*p*-methylanisoleazo-6-amino-*α*-naphthol-3-sulfonic acid: Na salt, 543 in H_2O; 538 in 0.02*N* HCl; 543 in 0.02*N* NaOH; 551 in 85% EtOH (436).

$C_{28}H_{23}N_5O_{11}S_3$.—3, 6-Disulfo-*α*-naphthaleneazo-*p*-methylanisoleazo-6-amino-*α*-naphthol-3-sulfonic acid: Na salt, 543 in H_2O; 538 in 0.02*N* HCl; 543 in 0.02*N* NaOH; 551 in 85% EtOH (436).

3, 6-Disulfo-*β*-naphthaleneazo-*p*-methylanisoleazo-6-amino-*α*-naphthol-3-sulfonic acid: Na salt, (582), 548 in H_2O; 546 in 0.02*N* HCl; 544 in 0.02*N* NaOH; 572, 546 in 85% EtOH (436).

$C_{29}H_{21}N_5O_7S$.—2-Amino-6-sulfo-*α*-naphtholazodiphenylazosalicylic acid (Na salt, C. I. 419): Diamine Fast Red F, 532.5 on silk (627).

$C_{29}H_{23}N_5O_4S$.—4-Sulfo-*α*-naphthylamineazodiphenylazocresol: (Na salt, C. I. 374): Erie Orange 2R, 483 in H_2O; 490 in 0.1*N* NaOH; 480 in EtOH (677).

$C_{30}H_{22}N_8O$.—Benzeneazobenzeneazobenzeneazobenzeneazophenol: 436 (111).

$C_{30}H_{25}N_5O_8S_2$.—*m*-Sulfobenzeneazo-*p*-methylanisoleazo-6-phenylamino-*α*-naphthol-3-sulfonic acid: Na salt, (603), 544 in H_2O; 534 in 0.02*N* HCl; 553 in 0.02*N* NaOH; 572, 546 in 85% EtOH (436).

p-Sulfobenzeneazo-*p*-methylanisoleazo-6-phenylamino-*α*-naphthol-3-sulfonic acid: Na salt, 545 in H_2O; 535 in 0.02*N* HCl; (590), 552 in 0.02*N* NaOH; 574, 548 in 85% EtOH (436).

$C_{30}H_{25}N_5O_{11}S_3$.—2, 4-Disulfobenzeneazo-*p*-methylanisoleazo-6-phenylamino-*α*-naphthol-3-sulfonic acid: Na salt, 556 in H_2O; 567 in 0.02*N* HCl; 559 in 0.02*N* NaOH; 579, 550 in 85% EtOH (436).

$C_{31}H_{25}N_5O_9S_2$.—*m*-Sulfobenzeneazo-*p*-methylanisoleazo-6-benzoylamino-*α*-naphthol-3-sulfonic acid: Na salt, 604, *520* in H_2O; (614), 518 in 0.02*N* HCl; 536 in 0.02*N* NaOH; 568, 537 in 85% EtOH (436).

p-Sulfobenzeneazo-*p*-methylanisoleazo-6-benzoylamino-*α*-naphthol-3-sulfonic acid: Na salt, (603), 536 in H_2O; (610), 525 in 0.02*N* HCl; 540 in 0.02*N* NaOH; 570, 538 in 85% EtOH (436).

$C_{31}H_{25}N_5O_{12}S_3$.—2, 4-Disulfobenzeneazo-*p*-methylanisoleazo-6-benzoylamino-*α*-naphthol-3-sulfonic acid: Na salt, (603), 539 in H_2O; 532 in 0.02*N* HCl; (596), 544 in 0.02*N* NaOH; 575, 544 in 85% EtOH (436).

$C_{31}H_{27}N_5O_8S_2$.—4-Sulfo-2-methylbenzeneazo-*p*-methylanisoleazo-6-phenylamino-*α*-naphtholsulfonic acid: Na salt, (605), 542 in H_2O; 532 in 0.02*N* HCl; 548 in 0.02*N* NaOH; 571, 546 in 85% EtOH (436).

$C_{32}H_{22}N_4O_2$.—Diphenyldisazo-*bis*-*β*-naphthol (C. I. 381): 640.6, 595.1 in H_2SO_4 (190).

$C_{32}H_{22}N_4O_8S_2$.—Diphenyldisazo-*bis*-*α*-naphthol-2-sulfonic acid: Na salt (424q).

$C_{32}H_{22}N_4O_{11}S_3$.—Diphenyldisazo-8-sulfo-*β*-naphthol-*α*-naphthol-4, 8-disulfonic acid (Na salt, C. I. 386): metallic salts in H_2O; Al, 542, Ba, 540, Cu, 515 (677).

$C_{32}H_{23}N_5O_7S_2$.—Diphenyldisazo-8-sulfo-*β*-naphthol-*α*-naphthylamine-4-sulfonic acid (Na salt, C. I. 376): Congo Rubine (498).

Diphenyldisazo-4-sulfo-*α*-naphthylamine-*α*-naphthol-4-sulfonic acid (Na salt, C. I. 375): (269). Metallic salts in H_2O; Na, 520, Al, 518, Cu, 495 (677).

$C_{32}H_{23}N_7O_{10}S_3$.—*p*-Sulfobenzeneazo-*o*-sulfobenzeneazo-*α*-naphthaleneazo-6-amino-*α*-naphthol-3-sulfonic acid: Na salt, 576 in H_2O (572 with alkali, 578 with acid) (436).

$C_{32}H_{23}N_7O_{13}S_4$.—*p*-Sulfobenzeneazo-*o*-sulfobenzeneazo-7-sulfo-*α*-naphthaleneazo-6-amino-*α*-naphthol-3-sulfonic acid: Na salt, 555 in H_2O (551 with alkali, 566 with acid) (436).

p-Sulfobenzeneazo-*o*-sulfobenzeneazo-7-sulfo-*α*-naphthaleneazo-6-amino-*α*-naphthol-4-sulfonic acid: Na salt, 581 in H_2O (569 with alkali, 580 with acid) (436).

$C_{32}H_{24}N_6O_6S_2$.—Diphenyldisazo-*bis*-*α*-naphthylamine-4-sulfonic acid (Na salt, Congo Red, C. I. 370): 497, 319 in alk. EtOH; 577, (320) in dil. H_2SO_4 (215); *cf.* (468, 525); 500 on cotton (627); influence of concn. (269); quant. data (162q).

$C_{32}H_{24}N_6O_7S_2$.—Diphenyldisazo-4-sulfo-*α*-naphthylamine-7-amino-*α*-naphthol-3-sulfonic acid (Na salt): Pontamine Bordeaux B, metallic salts in H_2O; Na, 510, Ba, 505, Cr, 480, Al, 480 (677).

$C_{32}H_{24}N_6O_8S_2$.—Diphenyldisazo-*bis*-7-amino-*α*-naphthol-3-sulfonic acid (Na salt, C. I. 394): Pontamine Violet N, 520 in H_2O (concd.); 525 (dil.) (269); 545 in EtOH (266); Ba salt, 510 in H_2O (677). Erie Violet 3R identical with above when heated. When dissolved in cold—640, 585 in H_2O (545 in EtOH) (269); *cf.*(266); Ba salt, 635, 590 in H_2O (677).

$C_{32}H_{24}N_6O_{14}S_4$.—Diphenyldisazo-*bis*-8-amino-*α*-naphthol-3, 6-disulfonic acid (Na salt, C. I. 406): Pontamine Blue BBF, metallic salts in H_2O; Na, Ba, 580, Cu, 590, Al, 570, Cr, 595 (677).

$C_{32}H_{27}N_5O_9S_2$.—4-Sulfo-2-methylbenzeneazo-*p*-methylanisoleazo-6-benzoylamino-*α*-naphthol-3-sulfonic acid: Na salt, 641, (598), 530 in H_2O; 638, 522 in 0.02*N* HCl; (630), 542 in 0.02*N* NaOH; 571, 542 in 85% EtOH (436).

$C_{32}H_{27}N_9$.—Benzeneazobenzeneazobenzeneazobenzeneazodimethylaniline: 514 (111).

$C_{33}H_{25}N_5O_6S_2$.—*m*-Sulfobenzeneazo-*α*-naphthaleneazo-*p*-tolyl-*α*-naphthylamine-8-sulfonic acid (Na salt, C. I. 289): influence of neutral salts (635, 636); influence of concn. (269).

$C_{33}H_{26}N_8O_{15}S_4$.—3, 3′-Disulfodiphenylurea-4, 4′-disazo-*bis*-7-amino-*α*-naphthol-3-sulfonic acid (Na salt, C. I. 353): soln. and dyeing (22); influence of concn. (269).

$C_{34}H_{24}N_8O_{10}S_2$.—Phenolazodiphenylazo-8-amino-3, 6-disulfo-*α*-naphtholazo-*p*-nitrobenzene (Na salt, C. I. 593): Pontamine Green X (269).

$C_{34}H_{26}N_4O_2$.—Ditolyldisazo-*bis*-*β*-naphthol: 654.2, 606.1 in H_2SO_4 (190).

$C_{34}H_{26}N_4O_4$.—Dimethoxydiphenyldisazo-*bis*-*β*-naphthol (C. I. 499): 663.2, 614.2 in H_2SO_4 (190).

$C_{34}H_{26}N_4O_{10}S_2$.—Dimethoxydiphenyldisazo-*bis*-*α*-naphthol-4-sulfonic acid (Na salt, C. I. 502): Pontamine Blue AX, metallic salts in H_2O; Na, 552, Cr, 550, Ba, 540, Al, Cu, 520 (677).

$C_{34}H_{27}N_5O_8S_2$.—7-Sulfo-*α*-naphthaleneazo-*p*-methylanisoleazo-6-phenylamino-*α*-naphthol-3-sulfonic acid: Na salt, 560 in H_2O; 569 in 0.02*N* HCl; 550 in 0.02*N* NaOH (436).

$C_{34}H_{27}N_5O_{11}S_3$.—3, 6-Disulfo-*α*-naphthaleneazo-*p*-methylanisoleazo-6-phenylamino-*α*-naphthol-3-sulfonic acid: Na salt, (608), 556 in H_2O; 554 in 0.02*N* HCl; 553 in 0.02*N* NaOH (436).

3, 6-Disulfo-*β*-naphthaleneazo-*p*-methylanisoleazo-6-phenylamino-*α*-naphthol-3-sulfonic acid: Na salt, 555 in H_2O; 555 in 0.02*N* HCl; 558 in 0.02*N* NaOH; 582, 555 in 85% EtOH (436).

3, 6-Disulfo-8-amino-*α*-naphtholazoditolylazo-*α*-naphthol-4-sulfonic acid (Na salt, C. I. 472): Niagara Blue BR, 568 in H_2O at 23°; 567 at 49°; 565 at 76° (677).

$C_{34}H_{27}N_5O_{12}S_3$.—3, 7-Disulfo-*β*-naphtholazoethoxybenzidine-azo-7-amino-*α*-naphthol-3-sulfonic acid (Na salt, C. I. 492): 580 in H_2O (dissolved cold); 575 (dissolved hot); 565 in EtOH (266); *cf.* (269).

$C_{34}H_{27}N_5O_{14}S_4$.—3, 6, 8-Trisulfo-*β*-naphthaleneazo-*p*-methylanisoleazo-6-phenylamino-*α*-naphthol-3-sulfonic acid: Na salt, 562 in H_2O; 561 in 0.02*N* HCl; 560 in 0.02*N* NaOH; 580, 556 in 85% EtOH (436).

$C_{34}H_{28}N_6O_6S_2$.—Ditolyldisazo-*bis*-*α*-naphthylamine-4-sulfonic acid (Na salt, C. I. 448): Erie Red 4B, 490 in H_2O (concd.); 498 (dil.); 505 in EtOH (269). Purpurine 4B (DuP.), 490 in H_2O (concd.), 496 (dil.), 510 in EtOH (677). Benzopurpurine 4B (By), on cotton, 505 (627). Diamine Red 4B, 512.5 on cotton (627).

Ditolyldisazo-*bis*-*α*-naphthylamine-5-sulfonic acid (Na salt, C. I. 449). Metallic salts of Benzopurpurine 6B in H_2O: Na, Cu, Al, 500; Cr, 505 (677).

$C_{34}H_{28}N_6O_9S_2$.—Ethoxydiphenyldisazo-*bis*-7-amino-*α*-naphthol-3-sulfonic acid (Na salt, C. I. 493): Diamine Black BO, dissolved with heat, 600 in H_2O (concd.); 580 (dil.); dissolved cold, 580 in H_2O (concd.); 570 (dil.); 570 in EtOH (266); *cf.* (269).

$C_{34}H_{28}N_6O_9S_3$.—Ditolyldisazo-3, 6-disulfo-*β*-naphthylamine-*β*-naphthylamine-6-sulfonic acid (Na salt, Vital Red, C. I. 456): 500 in H_2O (269).

$C_{34}H_{28}N_6O_{14}S_4$.—Ditolyldisazo-*bis*-8-amino-*α*-naphthol-3, 6-disulfonic acid (Na salt, Trypan Blue, C. I. 477): 585 in H_2O (485q); *cf.* (473).

$C_{34}H_{28}N_6O_{16}S_4$.—Dimethoxydiphenyldisazo-*bis*-8-amino-*α*-naphthol-3, 6-disulfonic acid (Na salt, C. I. 520): Pontamine Sky Blue 5BX, 595 in H_2O (concd.), 603 (dil.) (269). Metallic salts in H_2O: Na, 603, Al, 605, Cr, 610, Ba, 610, Cu, 580 (677).

Dimethoxydiphenyldisazo-*bis*-8-amino-*α*-naphthol-5, 7-disulfonic acid (Na salt, C. I. 518): Pontamine Sky Blue 6BX, lakes with Methylene Blue (265). Metallic salts in H_2O; Na, 620, Cu, 620, 670, Cr, 590, Ba, 618 (677).

$C_{35}H_{27}N_5O_{12}S_3$.—3, 6-Disulfo-*β*-naphthaleneazo-*p*-methylanisoleazo-6-benzoylamino-*α*-naphthol-3-sulfonic acid: Na salt (601), 535 in H_2O; 516 in 0.02*N* HCl; 543 in 0.02*N* NaOH: 560 in 85% EtOH (436).

$C_{35}H_{27}N_5O_{15}S_4$.—3, 6, 8-Trisulfo-*β*-naphthaleneazo-*p*-methylanisoleazo-6-benzoylamino-*α*-naphthol-3-sulfonic acid: Na salt, (596), 540 in H_2O; 535 in 0.02*N* HCl; 543 in 0.02*N* NaOH; 576, 538 in 85% EtOH (436).

$C_{38}H_{27}N_7O_{10}S_3$.—*p*-Sulfobenzeneazo-*o*-sulfobenzeneazo-*α*-naphthaleneazo-6-phenylamino-*α*-naphthol-3-sulfonic acid: Na salt, 593 in H_2O (580 with alkali, 621 with acid) (436).

$C_{38}H_{27}N_7O_{13}S_4$.—*p*-Sulfobenzeneazo-*o*-sulfobenzeneazo-7-sulfo-*α*-naphthaleneazo-6-phenylamino-*α*-naphthol-3-sulfonic acid: Na salt, 575 in H_2O (556 with alkali, 578 with acid) (436).

p-Sulfobenzeneazo-*o*-sulfobenzeneazo-7-sulfo-*α*-naphthaleneazo-6-phenylamino-*α*-naphthol-4-sulfonic acid: Na salt, 601 in H_2O (580 with alkali, 608 with acid) (436).

$C_{39}H_{29}N_7O_{10}S_3$.—*p*-Sulfobenzeneazo-*o*-sulfobenzeneazo-*α*-naphthaleneazo-6-*p*-tolylamino-*α*-naphthol-3-sulfonic acid: Na salt, 595 in H_2O (587 with alkali, 620 with acid) (436).

$C_{39}H_{29}N_7O_{13}S_4$.—*p*-Sulfobenzeneazo-*o*-sulfobenzeneazo-7-sulfo-*α*-naphthaleneazo-6-*p*-tolylamino-*α*-naphthol-3-sulfonic acid: Na salt, 578 in H_2O (560 with alkali, 579 with acid) (436).

p-Sulfobenzeneazo-*o*-sulfobenzeneazo-7-sulfo-*α*-naphthaleneazo-6-*p*-tolylamino-*α*-naphthol-4-sulfonic acid: Na salt, 603 in H_2O; (576 with alkali, 604 with acid) (436).

$C_{46}H_{34}N_{10}O_{13}S_3$.—4-Sulfo-*α*-naphthaleneazo-3, 6-disulfo-*α*-naphthol-7-azo-*m*-toluylenediamineazodiphenylazosalicylic acid (Na salt, C. I. 561): Trisulfon Brown B (22).

Diazine Black D. R. Concd. (probably identical with Zambesi Black II): 560 in H_2O (concd.); 565 (dil.); 585 in EtOH (266, 269).

Diazo Dark Blue 3B: 560 in H_2O (concd.), 570 (dil.), 590 in EtOH (266, 269).

Pontachrome Yellow 3R: on wool (10).

Pontamine Copper Blue RRX (probably N. W. acid→benzidine →2-amino-8-naphthol-5-sulfonic acid): 545 in H_2O (concd.); 555 (dil.) (269). Metallic salts in H_2O: Na, 555, Ba, 550, Al, 510, Cu, 530 (677).

TABLE 3.—TRIPHENYLMETHANE DERIVATIVES

$C_{19}H_{10}Br_4O_2$.—*m*-Tetrabromobenzaurin (subst. in phenol residues): 583 in alk. H_2O (461).

$C_{19}H_{13}BrO_2$.—*o*-Bromobenzaurin (subst. in benzene residue): 568 in alk. H_2O (461).

m-Bromobenzaurin (subst. in benzene residue): 565 in alk. H_2O (461).

p-Bromobenzaurin (subst. in benzene residue): 539 in alk. H_2O (461).

$C_{19}H_{13}BrN_2O_4$.—*p*-Bromo-*p*-dinitrotriphenylmethane: 274 in EtOH; Na salt, 513 in EtOH and C_6H_6 (221).

$C_{19}H_{13}N_3O_6$.—*p*-Trinitrotriphenylmethane: Na salt, 549 in EtOH (221).

$C_{19}H_{14}O$.—Fuchsone: *381*, 262, 250 in EtOH; *462*, 402, (289), *248* in concd. H_2SO_4; 472, 381, 283, 278, 270 in EtOH + HCl; 286, *250*, in EtOH + KOH (491q); 379, (262) in $CHCl_3$ (219); (471 with excess $SnCl_4$ (438)); *cf.* (213, 218, 438, 442, 454, 470).

$C_{19}H_{14}O_2$.—Benzaurin: *435*, 343, (284), 275 in EtOH; *504*, 402, (284, 276, 266) in EtOH + HCl; *473*, 410, (292, 285?), 256 in concd. H_2SO_4; 567, 379, 296, *250* in EtOH + KOH; 345, 296, 247 in 33% KOH (489q); *cf.* (155, 438, 442, 454, 461, 463, 491q).

$C_{19}H_{14}O_3$.—Aurin: *463*, (385, 297, 276), 265 in EtOH; *476*, (428, 333, 298, 289), *260* in concd. H_2SO_4; *482*, (338, 309), 272, 266 in EtOH + HCl; *536*, (500), 283 in EtOH + KOH; (364), 298, *248* in concd. aq. KOH (491q); *cf.* (57, 155, 174, 196, 231, 454, 461, 525).

$C_{19}H_{14}O_4$.—*o*-Dihydroxybenzaurin (subst. in phenol residues): 516 in alk. H_2O (467).

$C_{19}H_{14}O_5$.—*o*-Dihydroxyaurin: 545 in alk. H_2O (467).

$C_{19}H_{14}O_5S$.—*m*-Sulfobenzaurin (subst. in benzene residue): 560 in alk. H_2O (461).

p-Sulfobenzaurin (subst. in benzene residue): 568 in alk. H_2O; 512 in acid H_2O (458).

m-Sulfobenzaurin (subst. in phenol residue): 559 in alk. H_2O (461).

$C_{19}H_{14}O_6$.—*o*-Trihydroxyaurin (resaurin): 498 in alk. EtOH (174).

m-Trihydroxyaurin (catechaurin): 583.5 in dil. $NaHCO_3$ soln. (461).

o-Hydroxy-*m*-dihydroxyaurin: 610 in alk. EtOH (174).

$C_{19}H_{15}Cl_3N_3(OAc)$.—*o*-Trichloro-*p*-rosaniline acetate: 533 in H_2O (440).

$C_{19}H_{15}N$.—Fuchsoneimine: 430 in acid H_2O (461); chloride, 435, 335, 258 in EtOH (440); *cf.* (463).

$C_{19}H_{15}NO$.—*p*-Aminofuchsone: 558 in H_2O (461).

$C_{19}H_{15}NO_2$.—*p*-Nitrotriphenylmethane: Na salt, 429 in EtOH + C_6H_6 (221).

o-Aminobenzaurin: 565 in H_2O (461).

p-Aminobenzaurin (C. I. 726): *539.1*, 486.4 in alk. EtOH; *530.3*, 477.4 in alk. H_2O (155); 497 in acid H_2O (461).

$C_{19}H_{15}Cl$.—Triphenylcarbonium chloride: abs. of alkylmercapto derivs. (54q).

$C_{19}H_{16}N(ClO_4)$.—*p*-Aminotriphenylcarbinol anhydride perchlorate: 485, 420, 310 in HOAc (314).

$C_{19}H_{16}N_2O$.—*p*-Diaminofuchsone (C. I. 726): 541 in H_2O (461).

$C_{19}H_{16}O$.—*p*-Hydroxytriphenylmethane: 278 in EtOH (442).

Triphenylcarbinol: 269, 265, 262, *259*, 253, 248, 242 in EtOH (492q); 431, 404, (289, 262, 241) in concd. H_2SO_4 (491q); *cf.* (219, 314, 470). Ethyl ether (7q). Methoxy derivs. (389q).

$C_{19}H_{16}O_2$.—*p*-Dihydroxytriphenylmethane: 289, *280*, 271, 264, 258 in EtOH (489); *cf.* (370, 490).

p-Hydroxytriphenylcarbinol: (8q).

$C_{19}H_{17}NCl$.—*p*-Aminotriphenylmethane chloride: 280 in EtOH (442).

$C_{19}H_{17}N_2Cl$.—*p*-Diaminotriphenylcarbinol anhydride chloride (Döbner's Violet): 561.6 in H_2O; 577 in EtOH (155); 568, 399, 305 in EtOH (442). Diacid salt, 480 (314); *cf.* (465).

$C_{19}H_{17}N_3O_9S_3$.—Sulfonated *p*-rosaniline (Na salt) and its mono- and trimethyl isomers (162q). Commercial acid fuchsine: infra-red abs., 0.8, (2.0?), 2.8, (4.2?), (4.7?), (5.2?), 6.2, 7.4, 8.3, 9.2, 9.8, (10.2?), (10.7?)μ (296); ultra-violet band, 294 in H_2O (308 with NH_4OH) (352); on silk (627); on wool (522); *cf.* (269, 421q).

$C_{19}H_{18}N_3Cl$.—*p*-Rosaniline (C. I. 676): base, *555*, 287 in EtOH (20); chloride, in H_2O, *540.3*, 483.7 (155); in EtOH, 547, (490), 295 (314); in *N* HCl, *588*, 405; in HCl, 476 (20); diacid salt, 585; triacid salt, 485 (314); in solid form (352); cyanide, 532, 290, 249 in EtOH (381); *cf.* (3, 162q, 269, 273q, 352, 461, 497, 509q).

With rosaniline (Fuchsine, C. I. 677): infra-red abs., 0.7, (1.7?), 2.8, (4.1?), (4.7?), 6.3, *7.5*, 8.6, (9.6), 11.1μ (296); (3.5, *6.5*, 8.2μ) (80); influence of concn. (269, 273); influence of temp. (57); *cf.* (286q, 334, 335); dyeings (522, 627); *cf.* (4, 114, 218, 299q, 508q).

$C_{20}H_{12}Br_4O_3$.—Tetrabromorosolic acid: 566.4 in alk. H_2O; 576.9 in alk. EtOH (350); influence of temp. (57).

$C_{20}H_{16}O_3$.—*p*-Methoxybenzaurin: 551 in alk. H_2O (467).

$C_{20}H_{16}O_3$.—Rosolic acid: 543.3 in alk. H_2O; 569.4 in alk. EtOH (350); *cf.* (497).

$C_{20}H_{17}OCl$.—*o*-Methoxytriphenylcarbonium chloride: 550 in HOAc-HCl mixture (54q).

p-Methoxytriphenylcarbonium chloride: 470 in HOAc-HCl mixture (54q).

$C_{20}H_{20}N_3(Cl)$.—Rosaniline chloride: infra-red abs., 0.9, (1.6?), (2.7?), 6.3, 7.2, 7.8, 9.0, (9.4), 10.1, (10.5?), (11.3?)μ (296); 544.5 in H_2O (155); ultra-violet band at 291 in EtOH (289 with NH_3) (352); *cf.* (3, 231q, 273q, 647q). Phenolate (275).

$C_{21}H_{18}N_2O_3$.—*p*-Nitro-*p*-dimethylaminofuchsone: "apparently 610" (467).

$C_{21}H_{19}NO$.—*p*-Dimethylaminofuchsone: 586 in alk. H_2O; 515, (530, 500) in acid H_2O (461); 468 in H_2SO_4 (470).

$C_{21}H_{19}NO_4$.—4-Dimethylamino-3′, 4′, 3″, 4″-tetrahydroxytriphenylcarbinol anhydride: 700 in alk. soln.; 595 in $NaHCO_3$ soln.; 565 in acid soln. (473).

$C_{21}H_{19}O_2Cl$.—*o*-Dimethoxytriphenylcarbonium chloride: 577, *495* in HOAc-HCl mixture (54q).

p-Dimethoxytriphenylcarbonium chloride; 500 in HOAc-HCl mixture (54q).

$C_{21}H_{20}NCl$.—*p*-Dimethylaminotriphenylcarbinol anhydride chloride: 485, 330, (290), (260) in very dil. acid (218); *cf.* (54q, 314, 442, 461, 464).

$C_{21}H_{21}N_2(Cl)$.—*sym.*-Dimethyl-*p*-diaminotriphenylmethane anhydride chloride: 587 in H_2O (155).

$C_{21}H_{22}N_3(Cl)$.—*asym.*-Dimethyl-*p*-rosaniline chloride: 547, 493 in H_2O (575 with acid) (467).

$C_{22}H_{21}O_3(Cl)$.—*o*-Trimethoxytriphenylcarbonium chloride: 546 in HOAc-HCl mixture (54q).

p-Trimethoxytriphenylcarbonium chloride: 480 in HOAc-HCl mixture (54).

$C_{22}H_{23}N_3O_9S_3$.—Ethylrosaniline trisulfonic acid (Na salt, C. I. 693): Red Violet 5RS, influence of concn. (269).

$C_{22}H_{24}N_3(Cl)$.—*p*-Triamino-*o*-tritolylcarbinol anhydride chloride (New Fuchsine, C. I. 678): 548.5 in H_2O (155); 541 in H_2O (concd.), 544 (dil.) (269); ultra-violet band at 292 in EtOH (290 with NH_3) (352); *cf.* (162q, 273q).

$C_{23}H_{16}O$.—Benznaphthaurin: 568 in H_2SO_4 (454).

$C_{23}H_{24}ClN_2(Cl)$.—*o*-Chloromalachite green: 630.1 in H_2O (151).

$C_{23}H_{24}N_2O$.—Tetramethyl-*p*-diaminofuchsone: 540, 286 in EtOH; 521, 283 in $CHCl_3$; 461, 278 in Et_2O (218).

$C_{23}H_{24}N_2O_3S$.—Tetramethyl-*p*-diaminotriphenylcarbinol-*o*-sulfonic acid anhydride: Na salt, 623.9 in H_2O (155).

$C_{23}H_{24}N_3O_2(Cl)$.—*o*-Nitromalachite green: 633.1 in EtOH (151).

m-Nitromalachite green: 635.7 in EtOH (151).

p-Nitromalachite green: 637 in EtOH (151); 642 in H_2O (467).

$C_{23}H_{25}N_2(Cl)$.—Malachite green (C. I. 657): infra-red abs., 0.7, 3.4, 4.3, (4.8?), 6.5, 7.4, *8.5*, (9.2), (10.6), (10.9), 11.2μ (296); 616, 430 in H_2O (271); (400, 305 (419q)); influence of acidity (218, 219, 271, 306, 314, 463); influence of temp. (286); *cf.* (3, 54q, 111, 155, 352, 465, 525).

sym.-Diethyl-*p*-diaminotriphenylmethane carbinol anhydride chloride: 589.8 in H_2O (155).

$C_{23}H_{25}N_2O(Cl)$.—*o*-Hydroxymalachite green: 620.7 in H_2O (*605.8*, 560.3 with alkali); 617.7 in EtOH (155); *cf.* (111, 467).

m-Hydroxymalachite green: 617.4 in H_2O; 618 in EtOH (155); *cf.* (111).

p-Hydroxymalachite green: 602.5 in H_2O (*568.7*, 518.6 with KOH); 599.5 in EtOH (*558.5*, 515.2 with KOH) (155); *cf.* (111, 174, 463).

$C_{23}H_{25}N_2O_2Cl$.—2, 4-Dihydroxymalachite green: 601 (acetate in EtOH + 1 mol HCl (111)).

3, 4-Dihydroxymalachite green: *603*, 505 in acid EtOH (174).

$C_{23}H_{25}N_2O_3(Cl)$.—2, 3, 4-Trihydroxymalachite green: *612*, 500 in acid EtOH (174); *cf.* (111).

$C_{23}H_{26}N_3(Cl)$.—*o*-Aminomalachite green: 616.2 in EtOH; 618.9 in H_2O; 635.4 in dil. HCl (155); *cf.* (539).

m-Aminomalachite green: 614.7 in EtOH; 615.9 in H_2O; 627.1 in dil. HCl (155); *cf.* (539).

$C_{23}H_{26}N_3$(Cl).—*p*-Aminomalachite green: 576.2, 532.1 in AmOH; *578*, 529.4 in EtOH; *586.3*, 513.6 in H_2O; 623.9 in dil. HCl (155); 420 in HCl (467); *cf.* (152, 539).

$C_{24}H_{26}N_2O_3S$.—Tetramethyl-*p*-diaminodiphenyl-*m*-tolylcarbinol-*o*-sulfonic acid anhydride: Na salt, 622.3 in H_2O (155).

$C_{24}H_{27}ClN_3$(Ac).—2-Chloro-3-amino-5-methylmalachite green: 614.5 in H_2O (541).

2-Chloro-4-amino-5-methylmalachite green: 617.5 in H_2O (541).

3-Chloro-2-amino-5-methylmalachite green: 594.6 in H_2O (541).

4-Chloro-2-amino-5-methylmalachite green: 613.4 in H_2O (541).

4-Chloro-3-amino-6-methylmalachite green: 620.4 in H_2O (541).

5-Chloro-3-amino-2-methylmalachite green: 617.6 in H_2O (541).

5-Chloro-3-amino-6-methylmalachite green: 632.2 in H_2O (541).

5-Chloro-4-amino-2-methylmalachite green: 611.5 in H_2O (541).

$C_{24}H_{27}N_2Cl$.—*o*-Methylmalachite green: 618 in H_2O; 619.5 in EtOH (155).

p-Methylmalachite green: 611.1 in H_2O, 614.7 in EtOH (155).

$C_{24}H_{27}N_2O$(Cl).—*o*-Methyl-*p*-hydroxymalachite green: 617 in slightly acid H_2O; 587 in alk. H_2O (461).

o-Methoxymalachite green: 602.1 in H_2O; 601.1 in EtOH (155).

p-Methoxymalachite green: 603 in H_2O; 603.6 in EtOH (155); 613, 465, 290 in dil. acid (218); *cf.* (111, 467).

$C_{24}H_{27}N_4O_2$(Ac).—2-Nitro-3-amino-5-methylmalachite green: 661.4 in H_2O (541).

2-Nitro-3-amino-6-methylmalachite green: 617.5 in H_2O (541).

3-Nitro-2-amino-5-methylmalachite green: 595.4 in H_2O (541).

5-Nitro-4-amino-2-methylmalachite green: 602.1 in H_2O (541).

$C_{24}H_{28}N_3$(Cl).—Pentamethyl-*p*-rosaniline: *583.3*, 529.5 in H_2O; *583.3*, 538.5 in EtOH (155).

Commercial Methyl Violet: infra-red abs., 2.9, (4.4), 6.4, *7.2*, *8.4*, (9.1?), (9.4), 10.6μ (somewhat different data with Paris Violet) (296); 540 in H_2O (concd.), 580 (dil.) (269); ultra-violet bands at 302, 247 in EtOH (260 with NH_3) (352); dyeings (170, 627); *cf.* (3, 162q, 274q, 419q).

Gentian Violet (274q); *cf.* (3, 114).

$C_{24}H_{28}N_3$(Cl).—2-Amino-5-methylmalachite green: 618.5 in H_2O; 635.3 in dil. HNO_3; 618.1 in EtOH (539).

3-Amino-2-methylmalachite green: 619.8 in H_2O; 619.2 in EtOH (155); *cf.* (539).

3-Amino-4-methylmalachite green: 612.3 in H_2O; 612.6 in EtOH (155); 624.1 in dil. HNO_3; 622.9 in acid EtOH (539).

3-Amino-6-methylmalachite green: 620.6 in H_2O; 631.4 in dil. HNO_3; 619.1 in EtOH (630.1 with HNO_3) (539).

4-Amino-2-methylmalachite green: 601 in H_2O; *590.4*, 536.6 in EtOH (155); influence of acidity (539).

4-Amino-3-methylmalachite green: *582.7*, 512.8 in H_2O; *578*, 529.9 in EtOH (155); 620.4 in dil. HNO_3 (539).

$C_{24}H_{28}N_3O_3S$(Ac). 2-Sulfo-4-amino-5-methylmalachite green: 617.2 in H_2O (541).

4-Sulfo-2-amino-5-methylmalachite green: 590.8 in H_2O (541).

5-Sulfo-3-amino-2-methylmalachite green: 632.5 in H_2O (541).

5-Sulfo-3-amino-6-methylmalachite green: 632.2 in H_2O (541).

$C_{25}H_{24}N_3O_2$(OAc).—Tetramethyl-*p*-diaminodiphenylisatinyl carbinol acetate: *599.1*, 498.4 in H_2O (540).

$C_{25}H_{28}N_2O_7S_2$.—2, 4-Disulfo-5-hydroxydiethyl-*p*-diaminophenylditolyl carbinol anhydride, Na salt (C. I. 715): Cyanole Extra, 612.5 in H_2O (606.3 with alkali); 611.3 in EtOH (267q). Cyanole FF, 622 on silk (627).

$C_{25}H_{29}N_2O$(Cl). *o*-Ethoxymalachite green: 606.7 in H_2O; 603.3 in EtOH (155).

p-Ethoxymalachite green: 605.3 in H_2O; 605.8 in EtOH (155).

$C_{25}H_{30}N_3$(Cl).—Hexamethyl-*p*-rosaniline (Crystal Violet, C. I. 681): *590.5*, 539.5 in H_2O; 591.1, 544.5 in EtOH (155); ultra-violet bands at 305, 249 in EtOH (260 with NH_3) (352); diacid salt, 626 (2% H_2SO_4); triacid salt 490–495 (HCl) (314); triacid salt, *440*, (312), 261 (H_2SO_4) (219); influence of concn. (269); dyeings (522, 627); lake with paper stock (265); in solid form, 540 (269); dye base, 590 in EtOH; 588 in Me_2CO; 490–495 in C_6H_6 (677); pseudo-base, 262 in EtOH (213); resorcinol addition product (278); cyanide, 268 in EtOH (381); *cf.* (2q, 54q, 111, 114q, 162q, 218, 274q, 276, 299q, 461, 463, 465, 518q).

$C_{26}H_{26}N_3O_2$(OAc).—Tetramethyl-*p*-diaminodiphenyl-*o*-methylisatinylcarbinol acetate: *594.3*, 503.7 in H_2O (540).

Tetramethyl-*p*-diaminodiphenyl-*p*-methylisatinylcarbinol acetate: 626.2 in H_2O (540).

$C_{26}H_{31}N_2$(Cl).—*p*-Isopropylmalachite green: *614*, 440 in H_2O; 462 in dil. H_2SO_4 (271).

$C_{26}H_{32}N_3$(Cl).—*m*-Dimethylamino-*o*-methylmalachite green: 618.9 in H_2O; 620.7 in EtOH (155).

m-Dimethylamino-*p*-methylmalachite green: 614.4 in H_2O; 615.6 in EtOH (155).

p-Dimethylamino-*o*-methylmalachite green: *589.2*, 545.5 in H_2O; *598.8*, 551.5 in EtOH (155).

p-Dimethylamino-*m*-methylmalachite green: *589.3*, 534.8 in H_2O; 590.6, 542.5 in EtOH (155).

Triethylrosaniline (Hofmann's Violet, C. I. 679): 540 in H_2O (concd.); 585 (dil.) (269); *cf.* (231).

$C_{26}H_{33}ClN_3$(Cl).—Heptamethyl-*p*-rosaniline (Methyl Green, C. I. 684): infra-red abs., 0.7, (2.0?), 3.0, 3.9, (4.5?), (5.1?), (5.5?), 6.3, 7.4, *8.8*, 10.3μ (296); *cf.* (3, 162q, 269, 511).

$C_{27}H_{27}N_3O_6S_2$.—Tetramethyltriaminodiphenyl-α-naphthylcarbinoldisulfonic acid anhydride, Na salt (C. I. 733): Intensive Blue, 612, (540) in H_2O (concd.); 615 (dil.) (269).

$C_{27}H_{32}N_2O_6S_2$.—Tetraethyldiaminotriphenylcarbinol-2, 4-disulfonic acid anhydride, Na salt (C. I. 672): Xylene Blue VS, 640 in H_2O; 632.5 in EtOH (267q).

Tetraethyldiaminotriphenylcarbinol-2, 5-disulfonic acid anhydride: Na salt, Alphazurine 2G, 640 in H_2O; 631.3 in EtOH (267q).

$C_{27}H_{32}N_2O_7S_2$.—2,4-Disulfo-5-hydroxytetraethyldiaminotriphenylcarbinol anhydride, Ca salt (C. I. 712): Patent Blue V, 637.5 in H_2O (627.5 with alkali); 630 in EtOH (267q); ultra-violet bands, 390, 305 (419); 410, 308 in EtOH (352); dyeings (522).

$C_{27}H_{32}N_2O_3S$. *o*-Sulfotetraethyldiaminotriphenylcarbinol anhydride: Na salt, 630.8 in H_2O (155).

$C_{27}H_{33}N_2$(Cl).—Tetraethyl-*p*-diaminotriphenylcarbinol anhydride chloride (Brilliant Green, C. I. 662): infra-red abs., *0.7*, 1.3, (5.2), 6.4, 7.1, 7.5, (8.5), *9.0*, 9.8, 10.8, 11.3μ (296); 623 in H_2O (155); influence of concn. (269); influence of temp. (426); dyeings (522, 627); solid dye (546); ultra-violet bands at 429, 313 in EtOH (352).

$C_{27}H_{33}N_2O$(Cl).—*m*-Hydroxybrilliant green: 623.6 in H_2O (155).

$C_{27}H_{34}N_3$(Cl).—*o*-Dimethyl crystal violet: 605 in H_2O; *605*, 560.3 in EtOH; 605.8, 562.5 in AmOH (155).

Tetraethyl-*p*-rosaniline: *591.4*, 517.7 in H_2O; *582.5*, 533 in EtOH; *580.7*, 535.7 in AmOH (155).

$C_{29}H_{21}$(Cl).—Phenyldiphenylnaphthylchloromethane: 595, *495* in HOAc-H_2SO_4 mixture; 620, 495 in C_6H_5OH (98).

$C_{29}H_{23}NO_2$. *p*-Dimethylamino-*p*-dihydroxyphenyldinaphthylcarbinol anhydride: 730 in H_2O (492 with acid) (467).

$C_{29}H_{29}N_4$(OAc).—*p*-Azobenzenemalachite green: 572 in EtOH + 1 mol HCl (111).

$C_{29}H_{29}N_4O$(OAc).—*m*-Azobenzene-*o*-hydroxymalachite green: 557 in EtOH + 1 mol HCl (111).

p-Azophenolmalachite green: 556 in EtOH + 1 mol HCl (111).

m-Azophenolmalachite green: 565 in EtOH + 1 mol HCl (111).

$C_{29}H_{29}N_4O_2$(OAc).—*p*-Azoresorcinolmalachite green: 565 in EtOH + 1 mol HCl (111).

m-Azophenol-*o*-hydroxymalachite green: 565 in EtOH + 1 mol HCl (111).

$C_{29}H_{29}N_4O_3(OAc)$.—*p*-Azopyrogallolmalachite green: 567 in EtOH + 1 mol HCl (111).

$C_{29}H_{30}N_3(Cl)$.—*p*-Phenylaminomalachite green: *594*, 538.5 in H_2O; *594*, 549.5 in EtOH; *594*, 552.6 in AmOH (31); *cf.* (152).

$C_{29}H_{32}N_3(Cl)$.—Tetramethylethyltriaminodiphenyl-α-naphthylcarbinol chloride (Victoria Blue R, C. I. 728): 565 in H_2O (concd.); 605 (dil.) (269).

$C_{30}H_{28}N_3(Cl)$.—Acridylmalachite green: 642 in H_2O (523).

$C_{30}H_{31}N_4O(OAc)$.—*p*-Azoanisolemalachite green: 561 in EtOH + 1 mol HCl (111).

$C_{30}H_{32}N_3(Cl)$.—*p*-Benzylaminomalachite green: *583.3*, 526.7 in H_2O; 583.3, 537.5 in EtOH; *583.5*, 540.5 in AmOH (155); *cf.* (152).

$C_{31}H_{33}N_3O_9S_3$.—Benzylpentamethyltriaminotriphenylcarbinoltrisulfonic acid anhydride (Na salt, Acid Violet 4BN, C. I. 695): 550 in H_2O (concd.); 590 (dil.) (269).

$C_{31}H_{34}N_3(Cl)$.—Benzylpentamethyl-*p*-rosaniline (Benzyl Violet, C. I. 683): *587*, 535.7 in H_2O (152); *cf.* (274q).

$C_{31}H_{34}N_5(OAc)$.—*p*-Azodimethylanilinemalachite green: 557 in EtOH + 1 mol HCl (111).

$C_{31}H_{42}N_3(Cl)$.—Hexaethyl-*p*-rosaniline (Ethyl Violet, C. I. 682): *596.1*, 545.5 in H_2O; *596*, 550.5 in EtOH; *596.6*, 552.6 in AmOH (155); influence of concn. (269, 274q).

$C_{32}H_{28}N_3(Cl)$.—Diphenylrosaniline and homologs (C. I. 689): Aniline Blue 2B (511q, 528q).

$C_{32}H_{29}N_3O_4S$.—Diphenyltriaminodiphenyltolylcarbinolsulfonic acid (Na salt, with triphenyl isomer, Alkali Blue, C. I. 704): (334q).

$C_{32}H_{35}N_3O_{10}S_3$.—Tetramethyl-*p*-tolyltriaminoethoxytriphenylcarbinoltrisulfonic acid anhydride (Na salt, C. I. 717): Pontacyl Violet 6BN, 540, 620 in H_2O (concd.); 620 (dil.); 610 in EtOH (269). Acid Violet 6BN (B), dyeings (522).

$C_{32}H_{36}N_3(Cl)$.—Tetramethylethylbenzyl-*p*-rosaniline: *585.7*, 535.7 in H_2O (152).

$C_{33}H_{32}N_3(Cl)$.—Tetramethylphenyltriaminodiphenyl-α-naphthyl carbinol anhydride chloride (Victoria Blue B, C. I. 729): *618.8*, (567) in H_2O (155); 565 in H_2O (concd.); 615 (dil.) (269). Base, 605 in EtOH; 482 in C_6H_6 (677).

$C_{34}H_{34}N_3(Cl)$.—Pentamethyl-α-naphthyl-*p*-rosaniline (Victoria Blue 4R, C. I. 690): 545 in H_2O (concd.); 590 (dil.) (269); *cf.* (3).

$C_{34}H_{39}N_3O_3S$.—Methyltetraethylphenyltriaminotriphenylcarbinolsulfonic acid anhydride (C. I. 700): Alkali Violet R, 540 in H_2O (concd.); 590 (dil.) (269).

$C_{35}H_{33}N_6O(OAc)$.—*p*-Azobenzeneazophenolmalachite green: 558 in EtOH + 1 mol HCl (111).

m-Azobenzeneazophenolmalachite green: 578 in EtOH + 1 mol HCl (111).

$C_{35}H_{34}N_6O$.—*p*, *p'*-Disazodimethylanilinetriphenylcarbinol: 505 in concd. HCl (111).

$C_{35}H_{34}N_6O_2$.—*p*-Hydroxy-*p'*, *p''*-disazodimethylanilinetriphenylcarbinol: 514 in concd. HCl (111).

$C_{36}H_{38}N_7(OAc)$.—*p*-Azobenzeneazodimethylanilinemalachite green: 558 in EtOH + 1 mol HCl (111).

$C_{37}H_{29}N_3O_6S_2$.—Triphenyltriaminotriphenylcarbinoldisulfonic acid anhydride (Na salt, C. I. 705): Soluble Blue (DuP.), 550 in H_2O (concd.); 560 (dil.) (269).

$C_{37}H_{29}N_3O_9S_3$.—Triphenyltriaminotriphenylcarbinoltrisulfonic acid anhydride (Na salt, C. I. 706): Methyl Blue, ultra-violet band at (380) in H_2O (301 with NH_3) (352).

$C_{37}H_{30}N_3(Cl)$.—Triphenyl-*p*-triaminotriphenylcarbinol anhydride chloride: 594.8 in EtOH (155); 594.8 in H_2O (151).

$C_{37}H_{31}N_3O_4S$.—Triphenyltriaminotriphenylcarbinolsulfonic acid anhydride (Na salt, C. I. 703): Methyl Alkali Blue (M. L. B.), 585 in H_2O (concd.); 590 (dil.) (269); Alkali Blue (305) in H_2O (300 with NH_3) (352).

$C_{37}H_{36}N_2O_6S_2$.—Dibenzyldiethyldiaminotriphenylcarbinol-2, 4-disulfonic acid anhydride (Na salt, C. I. 673): 637.5 in H_2O; 630 in EtOH (267q).

Dibenzyldiethyldiaminotriphenylcarbinol-2, 5-disulfonic acid anhydride: Na salt, 637.5 in H_2O; 630 in EtOH (267q).

Dibenzyldiethyldiaminotriphenylcarbinoldisulfonic acid anhydride (Na salt, Guinea Green, C. I. 666): infra-red abs., *0.7*, 3.1, 5.2, 6.4, 7.2, 7.5, (8.2), *9.0*, 9.8, 10.8, 11.3μ (296); dyeings (522); *cf.* (211q).

$C_{37}H_{36}N_2O_7S_2$.—2, 4-Disulfo-5-hydroxydibenzyldiethyldiaminotriphenylcarbinol anhydride (Ca salt, Patent Blue A, C. I. 714): 637.5 in H_2O; (627.5 in alk.); 630 in EtOH (267q).

$C_{37}H_{36}N_2O_9S_3$.—Dibenzyldiethyldiaminotriphenylcarbinol-*p*, *p'*, *o''*-trisulfonic acid anhydride (NH_4 salt, Alphazurine FG, C. I. 671): 630 in H_2O; 628.8 in EtOH (267q).

Dibenzyldiethyldiaminotriphenylcarbinol-*p*, *p'*, *p''*-trisulfonic acid anhydride (Na salt, C. I. 670): 634, 425, 317 in H_2O (179q); 433, 313 in EtOH (311, 264 with NH_3) (352); dyeings (522, 590); *cf.* (419q, 422q, 519q).

$C_{37}H_{36}N_2O_{10}S_3$.—Fast Green FCF (*p*-hydroxyerioglaucine A): disodium salt, 628 in H_2O; trisodium salt, 611; indicator application (283q).

$C_{37}H_{37}N_3O_6S_2$.—Tetramethyl-*p*-diaminodibenzyl-*m*-aminotriphenylcarbinoldisulfonic acid anhydride (Na salt, C. I. 691): Fast Green extra, 628, 590 in H_2O (concd.); 622 (dil.); Fast Green CR and extra blue shade, 630 in concd. and dil. solns. (269).

$C_{37}H_{38}N_3(Cl)$.—Tetramethyldibenzyl-*p*-triaminotriphenylcarbinol anhydride chloride: *588*, 532 in H_2O; *588.5*, 542.5 in EtOH; *588.8*, 544.5 in AmOH (152).

$C_{37}H_{39}N_7O$.—*p*-Dimethylamino-*p'*, *p''*-disazodimethylanilinetriphenylcarbinol: 516 in concd. HCl (111).

$C_{38}H_{33}N_3(Cl)$.—Triphenylrosaniline: 596.1 in EtOH (155); 597.4 in H_2O (151).

$C_{38}H_{42}N_3(Cl)$.—Tetraethyl-*p*-tolyltriaminodiphenyl-α-naphthylcarbinol anhydride chloride (Night Blue, C. I. 731): 570 in H_2O (concd.); 620 (dil.) (269).

$C_{40}H_{35}N_3O_9S_3$.—Trimethyltriphenyltriaminotriphenylcarbinoltrisulfonic acid anhydride (Na salt, C. I. 708): Hoechst New Blue, 311 in H_2O (306 with NH_3) (352).

$C_{41}H_{38}N_8$.—*p*-Azobenzene-*p'*, *p''*-disazodimethylanilinetriphenylmethane: 507 in concd. HCl (111).

$C_{41}H_{38}N_8O$.—*p*-Azophenol-*p'*, *p''*-disazodimethylanilinetriphenylmethane: 507 in concd. HCl (111).

$C_{41}H_{46}N_3O_6S_2$.—Dibenzyltetraethyltriaminotriphenylcarbinoldisulfonic acid anhydride (Na salt, C. I. 698): Pontacyl Violet C4B, 540 in H_2O (concd.); 590 (dil.) (269); *cf.* (276); Formyl Violet S4B, 599.8 on silk (627).

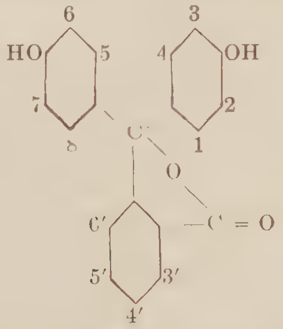
$C_{43}H_{43}N_9$.—*p*-Trisazodimethylanilinetriphenylmethane: 507 in concd. HCl (111).

$C_{46}H_{48}N_4(OAc)_2$.—Dimalachite green (diacetate): 622 (111).

Miscellaneous: Acid Violet, 300 in H_2O (309 with NH_3) (251); Acid Violet 4B extra (By), 530 in H_2O (concd.); 575 (dil.) (269); Acid Violet 6B, 535 in H_2O (concd.); 570 (dil.) (269); *cf.* (419); Alkali Blue 6B (By), 590 in H_2O (concd.); 580 (dil.) (269); Bavarian Blue DSF, 580 in H_2O (concd.); 595 (dil.) (269); Corallin, 460 in EtOH (concd.); 480 (dil.) (269); *cf.* (299q); Cotton Blue 6B extra, 311 in EtOH (294 with NH_3) (352); Guinea Violet 4B, dyeings (522); Iodine Green (231); Methyl Blue, infra-red abs., *0.7*, 3.3, 5.2, 6.5, 7.3, 8.7, 9.5, 10.2, 10.4, (10.8), 11.4μ (296); Neptune Green, infra-red abs. (296); New Patent Blue, 625 in H_2O; 617.5 in EtOH (26q); New Patent Blue 4B, 615 in H_2O, 608.8 in EtOH

(267q); Pontacyl Blue R, 575 in H_2O (concd.), 620 (dil.) (269); Pure Blue, 595 on cotton, *600*, 580 on silk (522); Water Blue, influence of concn. (299); Water Blue 6B, 305 (419q).

TABLE 4.—PHTHALEINS AND SULFONPHTHALEINS



See also Table 5 for other so-called phthaleins

$C_{19}H_{10}Br_2Cl_2O_5S$.—Dibromodichlorophenolsulfonphthalein ("Brom chlor phenol blue"): 596 in alk. soln. (81q); *cf.* (433q).

$C_{19}H_{10}Br_4O_5S$.—2, 3, 6, 7-Tetrabromophenolsulfonphthalein ("Brom phenol blue"): 593 in alk. soln. (81q); 440 in acid soln. (613q); *cf.* (58, 433q, 465).

$C_{19}H_{12}Br_2O_5S$.—Dibromophenolsulfonphthalein ("Brom phenol red"): 574 in alk. soln. (81q); *cf.* (433q).

$C_{19}H_{12}Cl_2O_5S$.—Dichlorophenolsulfonphthalein ("Chlor phenol red"): 573 in alk. soln. (81q); *cf.* (433q).

$C_{19}H_{14}O_5S$.—Phenolsulfonphthalein ("Phenol red"): 559 in alk. H_2O; 507 in acid H_2O, 435 in "mid-form" (270); *433*, (318), 265 in H_2O; *509*, (429, 396, 320, 284), 270 in abs. EtOH; *500*, 376, (327), 265 in concd. H_2SO_4; *562*, 360, 288 in alk. H_2O (178q); *cf.* (45, 58, 66q, 271, 288q, 433q, 455, 461, 465).

$C_{19}H_{14}O_7S$.—Catecholsulfonphthalein: 600 in $NaHCO_3$ soln.; 557 in dil. HCl (461).

$C_{20}H_4Cl_{10}O_4$.—1, 2, 3, 4, 5, 6, 7, 8, 4′, 5′-Dekachlorophenolphthalein: 642 in alk. H_2O (462).

$C_{20}H_6Br_4Cl_4O_4$.—2, 3, 6, 7-Tetrabromo-3′, 4′, 5′, 6′-tetrachlorophenolphthalein: 610, 377, 304 in alk. H_2O; 615, 306 in alk. EtOH (288q); *cf.* (45q, 287).

$C_{20}H_6Br_8O_4$.—2, 3, 6, 7, 3′, 4′, 5′, 6′-Octabromophenolphthalein: 608 in alk. H_2O; 577 in H_2SO_4 (454).

$C_{20}H_6Cl_4I_4O_4$.—3′, 4′, 5′, 6′-Tetrachloro-2, 3, 6, 7-tetraiodophenolphthalein: 621, 389, 308.5 in alk. H_2O; 625, 308 in alk. EtOH (288q); *cf.* (45q, 287).

$C_{20}H_7Br_7O_4$.—2, 3, 6, 7, 3′, 4′ (?), 5′-Heptabromophenolphthalein: 609 in alk. H_2O (462).

$C_{20}H_8Br_6O_4$.—2, 3, 4 (?), 6, 7, 5′ (?)-Hexabromophenolphthalein: 605 in alk. H_2O (462).

2, 3, 6, 7, 3′, 5′-Hexabromophenolphthalein: 602 in alk. H_2O (462).

2, 3, 6, 7, 3′, 6′-Hexabromophenolphthalein: 606 in alk. H_2O (462).

2, 3, 6, 7, 4′, 5′ (?)-Hexabromophenolphthalein: 592 in alk. H_2O (462).

$C_{20}H_9Br_4IO_4$.—2, 3, 6, 7-Tetrabromo-4-iodophenolphthalein: 600 in alk. H_2O (462).

$C_{20}H_9Br_4NO_6$.—2, 3, 6, 7-Tetrabromo-3′-nitrophenolphthalein: 597 in alk. H_2O (467).

2, 3, 6, 7-Tetrabromo-5′-nitrophenolphthalein: 599 in alk. H_2O (467).

$C_{20}H_9Br_5O_4$.—2, 3, 4, 6, 7-Pentabromophenolphthalein: 602 in alk. H_2O (462).

2, 3, 6, 7, 3′-Pentabromophenolphthalein: 597 in alk. H_2O (462).

2, 3, 6, 7 (4′ or 5′)-Pentabromophenolphthalein: 592 in alk. H_2O (462).

$C_{20}H_9I_5O_4$.—Pentaiodophenolphthalein ("probably two isomers"): 596 in alk. H_2O (462).

$C_{20}H_{10}Br_4O_4$.—2, 3, 6, 7-Tetrabromophenolphthalein: 580, 392, 305 in alk. H_2O; 588, 311.5 in alk. EtOH (288q); 529 in H_2SO_4 (454); *cf.* (45q, 287, 441, 445, 460, 638q).

3′, 4′, 5′, 6′-Tetrabromophenolphthalein: 583 in alk. H_2O (462); 501 in H_2SO_4 (454).

$C_{20}H_{10}Cl_4O_4$.—Tetrachloro-*o*, *p*-phenolphthalein: 576 (473).

2, 3, 6, 7-Tetrachlorophenolphthalein: 581.5, 303 in alk. H_2O; 590, 309 in alk. EtOH; 530 in H_2SO_4 (460); *cf.* (45q, 638q).

3′, 4′, 5′, 6′-Tetrachlorophenolphthalein: 303, 281, 272, 250 in abs. EtOH (178); 575, 362, 278 in alk. H_2O; 583, 364, 280 in alk. EtOH (288q); *cf.* (45q, 287, 467, 638q).

$C_{20}H_{10}I_4O_4$.—2, 3, 6, 7-Tetraiodophenolphthalein: 593.5, 400, 312.5 in alk. H_2O; 597, 313 in alk. EtOH (288q); *cf.* (45q, 287, 454, 458).

$C_{20}H_{11}Br_3O_4$.—2, 3, 6-Tribromophenolphthalein: 577 in alk. H_2O (462); *cf.* (638q).

3′ (4′ or 5′), 6′-Tribromophenolphthalein: 576 in alk. H_2O (462).

$C_{20}H_{12}Br_2O_3$.—2, 3-Dibromophenolphenylphthalein: 568 in alk. H_2O (454).

$C_{20}H_{12}Br_2O_4$.—2, 3-Dibromophenolphthalein: 570 in alk. H_2O (462); 506 in H_2SO_4 (460).

3, 6-Dibromophenolphthalein: 569 in alk. H_2O (462); *cf.* (638q).

3′, 5′-Dibromophenolphthalein: 571 in alk. H_2O (462).

3′, 6′-Dibromophenolphthalein: 573 in alk. H_2O (462).

$C_{20}H_{12}Br_2O_6$.—3, 6-Dibromocatecholphthalein: 720, 489 in alk. H_2O (454).

$C_{20}H_{12}Cl_2O_4$.—2, 3-Dichlorophenolphthalein: 569 in alk. H_2O 505 in H_2SO_4 (460).

2, 7-Dichlorophenolphthalein: 570 in alk. H_2O (460).

4, 5-Dichlorophenolphthalein: 597 in alk. H_2O (454).

$C_{20}H_{12}N_2O_8$.—3′, 5′-Dinitrophenolphthalein: 582 (473).

$C_{20}H_{13}BrO_4$.—Phenol-*p*-bromophenolphthalein: 559 in alk. H_2O (476).

3-Bromophenolphthalein: 561.5 in alk. H_2O (462).

4-Bromophenolphthalein: 567 in alk. H_2O (462).

3′-Bromophenolphthalein: 566 in alk. H_2O (462).

4′-Bromophenolphthalein: 556 in alk. H_2O (462).

5′-Bromophenolphthalein: 561 in alk. H_2O (462).

$C_{20}H_{13}ClO_4$.—1-Chlorophenolphthalein: 564 in alk. H_2O (462).

2-Chlorophenolphthalein: 560 in alk. H_2O; 502 in H_2SO_4 (460).

3′-Chlorophenolphthalein: 563 in alk. H_2O (462).

$C_{20}H_{13}IO_4$.—1-Iodophenolphthalein: 568.5 in alk. H_2O (462).

$C_{20}H_{13}NO_6$.—3′-Nitrophenolphthalein: 570 in alk. H_2O (467).

4′-Nitrophenolphthalein: 542 (473).

5′-Nitrophenolphthalein: 570 (473); *cf.* (467).

m-Nitro-*o*, *p*′-phenolphthalein: 588 in alk. H_2O (456).

$C_{20}H_{13}O_4$.—"Bridged phenolphthalein" (in 4, 5 positions): 555 (111).

$C_{20}H_{14}O_2$.—Diphenylphthalide: (283, 276, 269, 259, 253) in EtOH; *446*, (408), 305, *253* in concd. H_2SO_4 (490q).

$C_{20}H_{14}O_3$.—Phenylphenolphthalein (*p*-hydroxydiphenylphthalein): 395 in alk. H_2O (464); 262 in EtOH; 470 in H_2SO_4 (442); *cf.* (470).

$C_{20}H_{14}O_4$.—Isophenolphthalein (*o*, *p*′-phenolphthalein): 285, 277 in EtOH; (500), *449*, (426), (286), (260) in H_2SO_4; 294, 243 in 33% KOH soln.; 590, 410 in alk. EtOH (487); 552 in alk. soln. (475); *cf.* (490).

Phenolphthalein: 284, 277 in EtOH; *494*, 391, (324, 281, 260) in concd. H_2SO_4; 560, (367, 294), *253* in EtOH + KOH; 296, *248* in 33% aq. KOH (490); 552.5, 369, 286 in alk. H_2O; 562, 364 in alk. EtOH (288q); 570 in alk. Me_2CO (501); *cf.* (13, 45, 58, 111, 156, 178, 195, 197, 262q, 287, 433q, 439q, 441, 442, 444q, 445, 454, 458, 461, 487, 583q, 638q).

Phenolisophthalein: 560 in alk. H_2O (461).

$C_{20}H_{14}O_4$.—Phenolterephthalein: 550 in alk. H_2O (461); *cf.* (462).

Resorcinolphenylphthalein: 498 in H_2SO_4 (454).

$C_{20}H_{14}O_5$.—3′-Hydroxyphenolphthalein: 556 in H_2O with NaOH; 562 with $NaHCO_3$ (467).

4′-Hydroxyphenolphthalein: 542 in alk. H_2O; 481 in H_2SO_4 (454).

Phenolpyrocatecholphthalein: 579 in alk. H_2O; 552 in H_2SO_4 (455); *cf.* (550).

Phenolhydroquinolphthalein (*p*-Hydroxyisophenolphthalein): 498 in alk. H_2O(Moir?).

$C_{20}H_{14}O_6$.—3′, 6′-Dihydroxyphenolphthalein: 549 in H_2O with NaOH; 563 with $NaHCO_3$ (467).

4′, 5′-Dihydroxyphenolphthalein: 558 in H_2O with NaOH; 568 with $NaHCO_3$ (467).

Pyrocatecholphthalein: alkali salt, 635 in H_2O; 600 in dil. NaOH soln.; 543.5 in H_2SO_4 (156); *cf.* (197, 454, 550).

$C_{20}H_{14}O_{10}S_2$.—2, 7-Disulfophenolphthalein: 577 in alk. H_2O (454).

$C_{20}H_{15}NO_3$.—Phenolanilinephthalein: 558 in alk. H_2O (455).

$C_{20}H_{15}NO_4$.—*o*-Amino-*o*, *p*′-phenolphthalein: 570 in alk. H_2O (473); (value given in (456) is erroneous).

$C_{20}H_{16}N_2O_4$.—*o*-Diaminophenolphthalein: 630 in alk. H_2O (454); (value of 610 given in (172) for "diaminophenolphthalein").

$C_{21}H_{12}Cl_4O_4$.—Tetrachloro-*o*, *p*′-phenol-*m*-cresolphthalein: 590 (473).

$C_{21}H_{14}Br_2O_4$.—2, 3-Dibromo-6-methylphenolphthalein: 573 in alk. H_2O; 511 in H_2SO_4 (460).

2, 3-Dibromo-8-methylphenolphthalein: 584 in alk. H_2O; 521 in H_2SO_4 (460).

$C_{21}H_{14}Br_4O_5S$.—2, 3, 6, 7-Tetrabromo-*m*-cresolsulfonphthalein ("Bromcresol Green"): 614 in alk. H_2O; 619 in alk. EtOH (281q); *cf.* (81q, 433).

$C_{21}H_{14}Cl_4O_5S$.—2, 3, 6, 7-Tetrachloro-*m*-cresolsulfonphthalein ("Chlorcresol Green"): 612 in alk. soln. (81q).

$C_{21}H_{14}O_5$.—Phenyl-*o*-hydroxybenzoic acid-phthalein (hydroxydiphenylphthalide-*o*-carboxylic acid): 420 in weakly alk. H_2O (464); 471 in H_2SO_4 (470).

Phenyl-*p*-hydroxybenzoic acid-phthalein: 486 in alk. H_2O (457).

$C_{21}H_{14}O_6$.—Phenolphthalein-*o*-carboxylic acid: 561 in H_2O with NH_3; 567 with NaOH (456).

Isophenolphthalein-*m*-carboxylic acid: 562 in very weak alkali; 570 in strong alkali; 502 in H_2SO_4 (456).

$C_{21}H_{15}BrO_4$.—Phenolbromo-*o*-cresolphthalein: 570 in alk. H_2O (476).

Phenolbromo-*p*-cresolphthalein: 569 in alk. H_2O (476).

$C_{21}H_{15}IO_4$.—2-Iodo-3-methylphenolphthalein: 576 in alk. H_2O (473).

Phenol-6-iodo-*o*-cresolphthalein: 576 in alk. H_2O (476).

$C_{21}H_{16}Br_2O_5S$.—Dibromo-*o*-cresolsulfonphthalein ("Bromcresol Purple"): 591 in alk. H_2O (58q); *cf.* (66q). Ultra-violet abs. (21).

$C_{21}H_{16}O_3$.—Phenyl-*o*-cresolphthalein: 564 in alk. H_2O (454).

Phenyl-*m*-cresolphthalein: 506 in H_2SO_4 (457).

$C_{21}H_{16}O_4$.—Phenol-*o*-cresolphthalein: 562 in alk. H_2O (476); *cf.* (455).

Phenol-*m*-cresolphthalein: 569 in alk. H_2O; 526 in H_2SO_4 (457); *cf.* (476).

Phenol-*p*-cresolphthalein: 563 in alk. H_2O (476); 572 in alk. H_2O; 487 in H_2SO_4 (456).

Phenolphthalein methyl ether: 555 in alk. H_2O; 503 in H_2SO_4 (457).

Phenolphthalein methyl ester: 560 in alk. H_2O (567 in strong alkali); 523 in H_2SO_4 (458); *cf.* (439).

$C_{21}H_{16}O_5$.—Phenolguaiacolphthalein: 580 in alk. H_2O; 525 in H_2SO_4 (455).

5′-Methoxyphenolphthalein: 565 in alk. H_2O (467).

$C_{21}H_{17}NO_3$.—Phenolmethylanilinephthalein: 576 in alk. H_2O (455).

m-Methylaminoisophenolphthalein: 640 in alk. H_2O (456).

$C_{21}H_{18}O_5S$.—*o*-Cresolsulfonphthalein ("Cresol Red"): 437, (318), 287 in H_2O; *525*, (426), 406, (320), 276 in abs. EtOH; *509*, 381, (284, 265) in concd. H_2SO_4; *573*, 367, 294 in alk. aq. soln. (178); *cf.* (58q, 66q, 433q).

m-Cresolsulfonphthalein ("Metacresol Purple"): 580 in alk. soln.; 533 in acid soln. (81q).

$C_{21}H_{18}O_7S$.—Guaiacolsulfonphthalein: 608 in alk. H_2O; 565 in *N* HCl; 570 in H_2SO_4 (455).

$C_{22}H_{14}Br_4O_4$.—Tetrabromophenolphthalein ethyl ester (638q).

$C_{22}H_{14}Cl_4O_4$.—*o*-Cresol-3′, 4′, 5′, 6′-tetrachlorophthalein: 305, 282, 275, 253 in abs. EtOH (178).

$C_{22}H_{14}O_8$.—*o*-Dicarboxyphenolphthalein: 559 in alk. H_2O (454).

m-Dicarboxyphenolphthalein: 559 in alk. H_2O (454).

$C_{22}H_{14}O_{10}$.—Protocatechuicphthalein: 612 in alk. H_2O (454).

$C_{22}H_{16}Br_2O_4$.—*o*-Dibromo-*o*-cresolphthalein: 578 in alk. H_2O; 530.5 in H_2SO_4 (454).

$C_{22}H_{16}Br_2O_6$.—Dibromoguaiacolphthalein: 673 in alk. H_2O (454).

$C_{22}H_{16}O_6$.—*p*-Carboxyisophenolphthalein methyl ether: 558 in alk. H_2O; 503 in H_2SO_4 (456).

$C_{22}H_{18}O_4$.—*o*-Cresolphthalein: 569.5 in alk. H_2O; 577 in alk. EtOH (156); 587 in AmOH (458); 284, 277 in abs. EtOH; *508*, 386, (322), 282, (267), 234 in concd. H_2SO_4 (178); *cf.* (195, 197, 454, 476).

m-Cresolphthalein: 576 in alk. H_2O; 583 in alk. EtOH (156); *cf.* (197, 457, 476).

Phenolphthalein dimethyl ether: 518 in H_2SO_4; 521 in $CHCl_3$ + $SnCl_2$ (314); *cf.* (457).

Phenol-*asym.*-*o*-xylenolphthalein: 578 in alk. H_2O (476).

Phenol-*adj.*-*o*-xylenolphthalein: 575 in alk. H_2O (476).

Phenol-4-hydroxy-*o*-xylenephthalein: 573 in alk. H_2O (473).

Phenol-*adj.*-*m*-xylenolphthalein: 570 in alk. H_2O (476).

Phenol-*asym.*-*m*-xylenolphthalein: 573 in alk. H_2O (476); *cf.* (473).

Phenol-*sym.*-*m*-xylenolphthalein: 572 in alk. H_2O (476).

Phenol-*p*-xylenolphthalein: 574 in alk. H_2O (476); *cf.* (473).

$C_{22}H_{18}O_5$.—Phenolhydroquinolphthalein ethyl ether: 552, (490) in alk. H_2O (457).

$C_{22}H_{18}O_6$.—Guaiacolphthalein: 597 in alk. H_2O; 602 in alk. EtOH (156); *cf.* (197, 454).

3′, 6′-Dimethoxyphenolphthalein: 568 in alk. H_2O (467).

4′, 5′-Dimethoxyphenolphthalein: 556 in alk. H_2O (467).

5′, 6′-Dimethoxyphenolphthalein: 571 in alk. H_2O (467).

$C_{22}H_{19}NO_2$.—Phenyldimethylanilinephthalein: 480 in alk. H_2O (464).

$C_{22}H_{19}NO_3$.—Phenoldimethylanilinephthalein: 587.5 in alk. H_2O (455); 430 in H_2SO_4 (470).

$C_{22}H_{20}O_6S$.—Hydroxyisopropylphenolsulfonphthalein: 598 in alk. H_2O; 507 in acid H_2O (271).

$C_{23}H_{14}O_5$.—Phenolcoumarinphthalein: 565 in alk. H_2O (455).

$C_{23}H_{15}NO_7S$.—Phenolquinosolphthalein: 598 in alk. H_2O; 520 in H_2SO_4 (455).

$C_{23}H_{20}O_4$.—Phenolpseudocumenolphthalein: 581 in alk. H_2O (476).

$C_{23}H_{22}O_5S$.—Phenolsulfonphthalein diethyl ether: (509, 402, 310, 282, 275, 268) in EtOH (178).

$C_{23}H_{24}N_2O_3S$.—*bis*-Dimethylanilinesulfonphthalein: 593 in H_2O; 634 in acid H_2O (461).

$C_{24}H_{12}Cl_4O_4$.—Tetrachloro-*o*, *p*-phenol-α-naphtholphthalein: 630 (473).

$C_{24}H_{16}O_3$.—Phenyl-α-naphtholphthalein: (454, 467).

$C_{24}H_{16}O_4$.—*p*, *o*′-Phenol-α-naphtholphthalein: 612 in alk. H_2O (476); *cf.* (455).

$C_{24}H_{16}O_4$.—*p*, *p′*-Phenol-α-naphtholphthalein: 601 in NH_4OH soln.; 587 in concd. H_2SO_4 (473); *cf.* (476).

Phenol-β-naphtholphthalein: 570 in alk. H_2O (476); *cf.* (467).

$C_{24}H_{16}O_5$.—Resorcinol-α-naphtholphthalein: 468 in alk. H_2O (197).

$C_{24}H_{17}NO_3$.—Phenol-α-naphthylaminephthalein: 740 in alk. H_2O (455).

$C_{24}H_{18}Cl_4O_4$.—Tetrachloro-*o*, *p′*-phenolthymolphthalein: 597 (473).

p-Xylenoltetrachlorophthalein: 625 (473).

$C_{24}H_{18}O_8$.—Methyl salicylate phthalein: 557 in alk. H_2O (454).

$C_{24}H_{20}O_4$.—Phenoltetrahydro-α-naphtholphthalein: 584 in alk. H_2O (476); 530 in H_2SO_4 (455).

$C_{24}H_{22}O_4$.—Phenolcarvacrolphthalein: 580 in alk. H_2O (455); *cf.* (476).

Phenolthymolphthalein: 578 in alk. H_2O; 520 in H_2SO_4 (455); *cf.* (476).

$C_{24}H_{22}O_4$.—*vic.-o*-Xylenolphthalein: 593 in alk. H_2O (476).

vic.-m-Xylenolphthalein: 581 in alk. H_2O (476).

p-Xylenolphthalein: 590 in alk. H_2O (476); *cf.* (473).

$C_{24}H_{22}O_6$.—3′, 6′-Dimethoxy-*o*-cresolphthalein: 580 in alk. soln. (195).

3, 6′-Dimethoxy-*m*-cresolphthalein: 585 in alk. soln. (195).

$C_{24}H_{28}O_4$.—Phenolmentholphthalein: 563 in alk. H_2O (455).

$C_{25}H_{18}O_4$.—α-Naphtholmethyl ether phenolphthalein: 470 in alk. soln.; 572 in concd. H_2SO_4 (473).

$C_{25}H_{24}O_4$.—Thymol-*m*-cresolphthalein: 590 in alk. H_2O; 530 in H_2SO_4 (457).

Thymol-*p*-cresolphthalein: 595 in alk. H_2O (457).

$C_{25}H_{26}O_5S$.—*o*-Cresolsulfonphthalein diethyl ether: 525, (394, 318), (284, 275, 269), *237* in EtOH (178).

$C_{26}H_{18}O_6$.—Phenolnaphthoxyacetic acid phthalein: 485 in slightly alk. soln.; 592 in concd. H_2SO_4 (473).

$C_{26}H_{19}NO_3$.—Phenoldiphenylaminephthalein: 565 in alk. H_2O (456).

$C_{26}H_{21}NO_3$.—Phenoldimethyl-α-naphthylaminephthalein: 625 in alk. soln. (467).

$C_{26}H_{26}O_4$.—*p*-Ethoxyphenolthymolphthalein: 598 in alk. H_2O (457).

$C_{27}H_{18}O_5S$.—α-Naphtholsulfonphthalein: 730 in alk. H_2O; 720, 500 in H_2SO_4 (455).

$C_{27}H_{28}Br_2O_5S$.—Dibromothymolsulfonphthalein ("Bromthymol Blue"): 617 in alk. H_2O (58q); ultra-violet abs. (21); *cf.* (66q, 433q).

$C_{27}H_{30}O_5S$.—Carvacrolsulfonphthalein: 593 in alk. H_2O, 603 in alk. EtOH (677).

Thymolsulfonphthalein ("Thymol Blue"): 596 in alk. H_2O; 544 in acid H_2O (58q); 570 in H_2SO_4 (455); *cf.* (280q, 433q).

$C_{28}H_{14}Br_4O_4$.—α-Naphtholtetrabromophthalein: 678 in alk. H_2O; 654 in H_2SO_4 (454).

$C_{28}H_{17}NO_6$.—3′-Nitro-α-naphtholphthalein: 730 in alk. H_2O (455).

$C_{28}H_{18}O_4$.—*o*, *o′*-α-Naphtholphthalein: 671 in alk. H_2O; about 625 in concd. H_2SO_4 (473).

p, *p′*-α-Naphtholphthalein: 650 in alk. H_2O (476); *cf.* (156, 197, 454, 458, 66q).

Phenol-α-anthrolphthalein: 628 in alk. H_2O; 611 in H_2SO_4 (457).

Phenol-β-anthrolphthalein: 730 in alk. H_2O (457).

$C_{28}H_{18}O_5$.—3′-Hydroxy-α-naphtholphthalein: 622 in alk. H_2O (454).

$C_{28}H_{24}O_4$.—Thymol-α-naphtholphthalein: 633 in alk. H_2O (457).

Thymol-β-naphtholphthalein: 700 in alk. H_2O (457).

$C_{28}H_{26}Br_4O_4$.—Thymoltetrabromophthalein: 623 in alk. H_2O; 575 in H_2SO_4 (454).

$C_{28}H_{26}O_4$.—Tetrahydronaphtholphthalein: 602 in alk. H_2O (454).

$C_{28}H_{28}Br_2O_4$.—Dibromocarvacrolphthalein: 623 in alk. H_2O (454).

Dibromothymolphthalein: 625 in alk. H_2O (454).

$C_{28}H_{29}NO_6$.—3′-Nitrothymolphthalein: 602 in alk. H_2O (455).

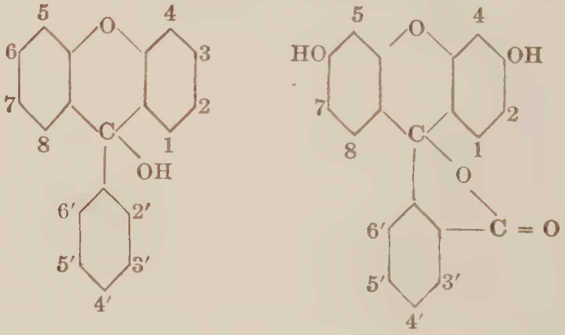
$C_{28}H_{30}O_4$.—Carvacrolphthalein: 602 in alk. H_2O (156); 554 in H_2SO_4 (454); *cf.* (197, 476).

Thymolphthalein: 596.5 in alk. H_2O; 603 in alk. EtOH (156); 548 in H_2SO_4 (454); ultra-violet band at 398 in alk. H_2O (458); *cf.* (58q, 197, 476).

$C_{32}H_{26}O_4$.—Thymol-α-anthrolphthalein: "probably" 710 in alk. H_2O; 636 in H_2SO_4 (457).

$C_{36}H_{22}O_4$.—α-Anthrolphthalein: 740 in alk. H_2O; 720 in H_2SO_4 (457).

TABLE 5.—XANTHENE DYES



$C_{13}H_8O_2$.—Xanthone: 333, 282 (also gives data on xanthene) (608); 405, 340 in H_2SO_4 (470).

$C_{13}H_8O_3$.—3-Hydroxyfluorone: 504 in EtOH + HCl (644).

$C_{13}H_8O_4$.—3, 6-Dihydroxyxanthone: 381 in EtOH + HCl (644).

$C_{13}H_{10}O_2$.—Xanthydrol: 450 in H_2O (470).

$C_{13}H_{10}O_4$.—3, 6-Dihydroxyxanthydrol: 479 in H_2O (465).

$(C_{15}H_{15}N_2O)_2SO_4$.—*sym.*-Dimethyldiaminoxanthenyl sulfate: 583 in EtOH (44q).

$C_{17}H_{18}N_2O_2$.—3, 6-Tetramethyldiaminoxanthone: 386.1 in EtOH + HCl (644).

$C_{17}H_{19}N_2O(Cl)$.—Tetramethyldiaminoxanthenyl chloride (Pyronine G, C. I. 739): *547.5*, 505.6 in H_2O; 547.9, 511.2 in EtOH; 548.3, 512.8 in AmOH (155); 507 in H_2O (concd.), 545 (dil.) (677); *cf.* (111, 465, 644). Cyanpyronine G; *663*, 603, (280, 270) in EtOH (221).

$C_{19}H_8Br_4O_6S$.—Tetrabromoresorcinolsulfonphthalein: 527 in alk. H_2O (466).

$C_{19}H_9Br_4NO_6$.—2, 4, 5, 7-Tetrabromo-4′-nitroresorcinolbenzein: 527 in alk. H_2O (466).

$C_{19}H_{10}Br_2O_6S$.—Dibromosulfonfluorescein: (497.5), *462*, (393, 307, 283, 269), 262, 241 in abs. EtOH; *450*, (354, 340, 327, 304), *269*, (261, 234) in concd. H_2SO_4 (177q). Diacetate: (497), *464*, (447), 359, (303), 272, 265, *237* in abs. EtOH (177q).

$C_{19}H_{10}Br_4O_4$.—2, 4, 5, 7-Tetrabromoresorcinolbenzein: 519 in alk. H_2O (466).

$C_{19}H_{11}NO_8S$.—4′-Nitroresorcinolsulfonphthalein: 506 in alk. H_2O (466).

$C_{19}H_{12}O_6S$.—Sulfonfluorescein: (488), *446*, (315, 300, 264, 252), 230 in abs. EtOH; *439*, (333, 316, 291), *257*, (252, 225) in concd. H_2SO_4; *502.5*, (475, 379, 321, 293, 260), *243* in EtOH + KOH; diacetate, (482), *444*, (411, 293), *259* in abs. EtOH; dichloride, 309. 299, 266 in abs. EtOH (177q); Moir reports bands at (522), 497 in alk. H_2O and at 576 in *N* HCl for resorcinolsulfonphthalein (455).

$C_{19}H_{12}O_6S$.—Hydroquinolsulfonphthalein: (510), 443, 366, *284*, (242) in EtOH; (500), 432, 365, *280*, (241) in H_2O; (488), 403, 370, *274*, (241) in concd. H_2SO_4; 542, 375, 315, *249* in EtOH + KOH; 461, 325, 250 in 33% aq. KOH; dibenzoate, (458), 388, (302), 269, 227 in EtOH (584q).

$C_{19}H_{13}BrO_4$.—3′-Bromoresorcinolbenzein: 497 in alk. H_2O (466).

4′-Bromoresorcinolbenzein: 493 in alk. H_2O (466).

6′-Bromoresorcinolbenzein: 505 in alk. H_2O (466).

$C_{19}H_{13}BrO_5$.—3′-Bromo-4′-hydroxyresorcinolbenzein: 490 in H_2O (550 with alkali) (466).

$C_{19}H_{13}NO_5S$.—Resorcinolsaccharein: "spectrum identical with fluorescein" (455).

$C_{19}H_{13}NO_6$.—4′-Nitroresorcinolbenzein: 500 in alk. H_2O (466).

$C_{19}H_{14}O_4$.—Resorcinolbenzein: 490, *459*, (433, 370, 317, 312, 276, 270, 253) in EtOH; *446*, (348, 295, 262, 251) in EtOH + HCl; *426*, (370, 282), *256*, *251* in concd. H_2SO_4; *505*, (475, 379), 324, 292, (259), *242* in EtOH + KOH; *492*, (384), 327, 285, (256), *239* in 5% aq. KOH (493q); 501 in alk. H_2O; 442 in H_2SO_4 (454); 508 in EtOH (514, 478) with alkali) (429).

$C_{19}H_{14}O_5$.—3′-Hydroxyresorcinolbenzein: 494 in H_2O (492 with alkali) (466).

4′-Hydroxyresorcinolbenzein: 484 in H_2O; 492 in slightly alk. soln.; 544 with excess alkali (466).

6′-Hydroxyresorcinolbenzein: 492, 430 in H_2O (466).

$C_{19}H_{14}O_6$.—Hydroxyquinolbenzein: 500 in EtOH (523 with alkali) (429).

Pyrogallolbenzein: 496 in EtOH (535 with alkali) (429).

$C_{20}H_2I_{10}O_5$.—Dekaiodofluorescein: K salt, 549.5 in alk. H_2O; 556.5 in alk. EtOH (272).

$C_{20}H_4Br_3Cl_4IO_5$.—4, 5, 7-Tribromo-3′, 4′, 5′, 6′-tetrachloro-2-iodofluorescein: 543 in alk. H_2O (466).

$C_{20}H_4Br_4Cl_4O_3$.—Tetrabromotetrachlorofluoran: 311 in EtOH (287).

$C_{20}H_4Br_4Cl_4O_5$.—2, 4, 5, 7-Tetrabromo-3′, 4′, 5′, 6′-tetrachlorofluorescein (C. I. 778): K salt, *537.3*, 498.5 in H_2O; *549.9*, 509.5 in EtOH; 474.5 in H_2SO_4 (155); ultra-violet band at 307 in H_2O (352); *cf.* (272, 287, 466, 637); also (?) (3, 162q, 299, 497, 642).

$C_{20}H_4Br_4I_4O_5$.—2, 4, 5, 7-Tetrabromo-3′, 4′, 5′, 6′-tetraiodofluorescein: 540 in alk. H_2O; 551 in alk. EtOH (272).

3′, 4′, 5′, 6′-Tetrabromo-2, 4, 5, 7-tetraiodofluorescein: 548 in alk. H_2O; 560 in alk. EtOH (637).

$C_{20}H_4Br_8O_5$.—Octabromofluorescein: 539 in alk. H_2O; 550 in alk. EtOH (272); 553 in 0.1% HOAc; 520 in solid form (677); *cf.* (456, 637).

$C_{20}H_4Cl_4I_4O_5$.—3′, 4′, 5′, 6′-Tetrachloro-2, 4, 5, 7-tetraiodofluorescein (C. I. 779): Na salt, *547.7*, 507.3 in H_2O; *558.1*, 516.1 in EtOH; 490.5 in H_2SO_4 (155); 560 on wool (642); *cf.* (3, 162, 272, 466, 637).

$C_{20}H_4Cl_8O_5$.—Octachlorofluorescein: 537 in alk. H_2O (466).

$C_{20}H_4I_8O_5$.—Octaiodofluorescein: 550 in alk. H_2O; 558 in alk. EtOH (272).

$C_{20}H_5Br_4Cl_3O_5$.—2, 4, 5, 7-Tetrabromo-3′, 4′, 5′-trichlorofluorescein: 536 in alk. H_2O (466).

$C_{20}H_5Br_7O_5$.—2, 4, 5, 7, 3′, 5′, 6′-Heptabromofluorescein: 540 in alk. H_2O (466).

$C_{20}H_6Br_4Cl_2O_3S_2$.—2, 4, 5, 7-Tetrabromo-3′, 6′-dichlorothiofluorescein: 520.5 in H_2O + NH_3; 526.5 in EtOH + NH_3 (637).

$C_{20}H_6Br_4Cl_2O_5$.—2, 4, 5, 7-Tetrabromo-3′, 5′-dichlorofluorescein: 538 in alk. H_2O (466).

2, 4, 5, 7-Tetrabromo-3′, 6′-dichlorofluorescein (C. I. 774): K salt, *529.4*, 492 in H_2O; 541.1, 501.5 in EtOH; 466 in H_2SO_4 (155); 531.5 in alk. H_2O; 546.5 in alk. EtOH (637); 545 on wool (642); ultra-violet band at 305 in H_2O (352); *cf.* (676q).

2, 4, 5, 7-Tetrabromo-4′, 5′-dichlorofluorescein: 529 in alk. H_2O (466).

$C_{20}H_6Br_6O_5$.—2, 4, 5, 7, 3′, 5′-Hexabromofluorescein: 535 in alk. H_2O (466).

2, 4, 5, 7, 3′, 6′-Hexabromofluorescein: 539 in alk. H_2O (466); (538) (465).

$C_{20}H_6Cl_2I_4O_3S_2$.—2, 4, 5, 7-Tetraiodo-3′, 6′-dichlorothiofluorescein: 560 in H_2O + NH_3; 565 in EtOH + NH_3 (637).

$C_{20}H_6Cl_2I_4O_5$.—2, 4, 5, 7-Tetraiodo-3′, 6′-dichlorofluorescein (C. I. 777): Na salt, *538.1*, 499.5 in H_2O; *548.7*, 508 in EtOH; 483 in H_2SO_4 (155); 540 in alk. H_2O; 556.5 in alk. EtOH (637); ultra-violet band at 310 (352); infra-red abs., *8*, (1.3), 3.5, 5.4, 6.4, 7.0, 7.6, 9.1, (9.9), 10.3, 11.0μ (296); 560 on wool (642); *cf.* (388q, 390q, 391, 418q, 518q).

$C_{20}H_7Br_4NO_7$.—2, 4, 5, 7-Tetrabromo-3′-nitrofluorescein: 530 in alk. H_2O (466).

2, 4, 5, 7-Tetrabromo-5′-nitrofluorescein: 529 in alk. H_2O (466).

$C_{20}H_7Br_5O_5$.—2, 4, 5, 7, 3′-Pentabromofluorescein: 529 in alk. H_2O (466).

2, 4, 5, 7, 5′-Pentabromofluorescein: 526 in alk. H_2O (466).

$C_{20}H_7Cl_4IO_5$.—3′, 4′, 5′, 6′-Tetrachloro-2-iodofluorescein: 520 in alk. H_2O (466).

$C_{20}H_8Br_2N_2O_9$.—2, 7-Dibromo-4, 5-dinitrofluorescein: 522 in alk. H_2O (466).

4, 5-Dibromo-2, 7-dinitrofluorescein (C. I. 771): 535 on wool; 530 in gelatin (transmission); 541 (reflection) (642); 519 in H_2O: 530 in solid form (677); *cf.* (162q, 497).

$C_{20}H_8Br_4O_5$.—2, 4, 5, 7-Tetrabromofluorescein (Na salt, Eosin, C. I. 768): *516*, 482.5 in H_2O; *527.6*, 489.2 in EtOH; 545 in H_2SO_4 (155); 523 in alk. EtOH (272); 285 in slightly acid EtOH (287); 510 on wool (642); 533 in 1% HOAc; 520 in solid form (677); infra-red abs., *0.7*, *6.9*, (8.4), 9.2, 10.2μ (296); ultra-violet bands in H_2O at 344, 303 (352); *cf.* (335, 418); influence of temp., (57, 426); *cf.* (3, 114, 162q, 272, 299, 332, 390q, 391q, 445q, 447, 454, 497, 637).

3′, 4′, 5′, 6′-Tetrabromofluorescein: 510 in alk. H_2O; 521 in alk. EtOH (272); 438.5 in H_2SO_4 (454); *515*, 478 in solid form (677); *cf.* (466, 637).

$C_{20}H_8Cl_4O_3$.—3′, 4′, 5′, 6′-Tetrachlorofluoran: 309, *295* in EtOH (286).

$C_{20}H_8Cl_4O_5$.—2, 4, 5, 7-Tetrachlorofluorescein: 518 in alk. H_2O (466); (519) (460).

3′, 4′, 5′, 6′-Tetrachlorofluorescein: 509.5 in alk. H_2O; 520 in alk. EtOH (272); ultra-violet abs. (287); *cf.* (466, 637).

$C_{20}H_8Cl_4O_7$.—3′, 4′, 5′, 6′-Tetrachlorohydroxyhydroquinolphthalein: 577, 530 in alk. H_2O (466).

$C_{20}H_8I_4O_5$.—2, 4, 5, 7-Tetraiodofluorescein (Na salt, Erythrosin, C. I. 773): *526*, 351, 309, *260* in H_2O (179q); in EtOH, disodium salt, 531; monosodium salt, 541; dye acid, 490 (279); 467.5 in H_2SO_4 (155); 537.5 on wool (642); 542 on silk (627); *cf.* (10); influence of temp. (334q, 335q); infra-red abs. (0.9), 1.9, 3.1, 4.5, 6.4, *6.9*, 7.4, 8.1, 9.5, 10.2, 10.8, (11.4) μ (296); *cf.* (114q, 272, 454, 628, 629, 637).

3′, 4′, 5′, 6′-Tetraiodofluorescein: 511 in alk. H_2O; 522 in alk. EtOH (272); *532*, 500 in solid form (677).

$C_{20}H_8N_4O_{13}$.—2, 4, 5, 7-Tetranitrofluorescein: 489 in H_2O; 523.8 in EtOH (500.4 with alkali) (350).

$C_{20}H_9Br_3O_5$.—2, 4, 7-Tribromofluorescein: 515 in alk. H_2O (466).

3′, 5′ (or 4′), 6′-Tribromofluorescein: 511 in alk. H_2O (466).

$C_{20}H_9Cl_3O_5$.—3′, 4′, 5′-Trichlorofluorescein: 505 in alk. H_2O (466).

$C_{20}H_{10}Br_2O_5$.—2, 7-Dibromofluorescein: 509 in alk. H_2O (466); 508 (460).

4, 5-Dibromofluorescein: 505 in alk. H_2O; 510 in alk. EtOH (272); 520, 490 in solid form (677); *cf.* (155, 637).

$C_{20}H_{10}Br_2O_5$.—3′, 5′-Dibromofluorescein: 506 in alk. H_2O (466).

3′, 6′-Dibromofluorescein: 509 in alk. H_2O (466).

$C_{20}H_{10}Cl_2O_3$.—4, 4′-Dichlorofluoran: 295, 284, 275, 265 in abs. EtOH (494q).

$C_{20}H_{10}Cl_2O_3S_2$.—3′, 6′-Dichlorothiofluorescein: 530, 503 in $H_2O + NH_3$ (637).

$C_{20}H_{10}Cl_2O_5$.—3′, 6′-Dichlorofluorescein: 505 in alk. H_2O; 517.5 in alk. EtOH (637).

$C_{20}H_{10}I_2O_5$.—4, 5-Diiodofluorescein (Na salt, C. I. 772): 507 in alk. H_2O; 518 in alk. EtOH (637); 510.8 in H_2O (155).

$C_{20}H_{10}N_2O_9$.—4, 5-Dinitrofluorescein: salts (497).

$C_{20}H_{10}O_5S_2$.—Fluorescein disulfide: 509 in EtOH; 489.2 in alk. H_2O (395).

$C_{20}H_{11}BrO_5$.—3′-Bromofluorescein: 501 in alk. H_2O (466).

5′-Bromofluorescein: 499 in alk. H_2O (466).

$C_{20}H_{11}NO_7$.—3′-Nitrofluorescein: 500 in alk. H_2O (466).

5′-Nitrofluorescein: 498 in alk. H_2O (466).

$C_{20}H_{12}O_3$.—Fluoran: 293, 284, 278, 262 in abs. EtOH; (468, 447, 427), *378*, (362, 277), *259*, (253) in concd. H_2SO_4 (494q); *cf.* (287, 442, 454, 470, 473).

$C_{20}H_{12}O_3S_2$.—Thiofluorescein: 586 in alk. H_2O (172).

$C_{20}H_{12}O_5$.—Fluorescein (Na salt, C. I. 766): 482, 455, (431, 374, 289, 283), *277* in EtOH; *443*, (309, 298, 264, 249) in EtOH + HCl; *432*, (329, 311, 290, 256), 250 in concd. H_2SO_4 (494q); Na salt, *489.3*, 457.2 in H_2O; *498.5*, 465.7 in EtOH (155); 470 on wool (642); 500, 470 in solid form (677); influence of temp. (57); influence of pH (272); infra-red abs., 0.8, (1.3), 3.5, 5.4, 6.4, 7.0, 7.6, 9.1 (9.9), 10.3, 11.0μ (296); *cf.* (3, 111, 114, 156, 287, 351q, 395, 418q, 429, 441, 444, 445, 447q, 454, 466, 470, 497, 603, 666q). Diacetate, 291, 282, 273, 262 in abs. EtOH (494q); *o*-toluidide, 533; *p*-toluidide, 557 (396); anilide, 555 (396).

Hydroquinolphthalein: (517), 443, 363, *283*, (245) in EtOH + HCl; (484), 396, 366, *271*, (240) in concd. H_2SO_4; (526), 346, *261* in EtOH + KOH; 332, 247 in 33% aq. KOH (584q); 497.5 in H_2SO_4 (454); alkali salt: 494 in H_2O (466); 614, *506*, 367 (441); 498 in alk. H_2O (454); 516.4, (502), *486.5*, 456 in EtOH (156); *cf.* (287, 444q, 445). Dibenzoate: (299, 282, 272, 232) in EtOH (584q).

$C_{20}H_{12}O_6$.—3′-Hydroxyfluorescein: 489 in H_2O (494 with alkali) (466); 420 in H_2SO_4 (454).

4′- (or 5′-) Hydroxyfluorescein: 492 in H_2O (466).

o-Hydroxyfluorescein: 523, 498 (473, 550).

$C_{20}H_{12}O_7$.—1, 8-Dihydroxyfluorescein (Phloroglucinolphthalein): 489 in H_2O (466); 460 in H_2O (156); 496 in alk. H_2O (197); 500 in alk. EtOH (463 with excess alkali) (156); 433 in H_2SO_4 (454).

2, 7-Dihydroxyfluorescein (Hydroxyhydroquinolphthalein): 550, 527, 509 in alk. H_2O (466); *494.5*, 462 in EtOH; 554.5, 503 in alk. EtOH; 580.5 with Zn salt (156); *cf.* (197, 429, 550).

4, 5-Dihydroxyfluorescein (Gallein): 505 in slightly alk. H_2O; 540 with excess alkali (156); 561.8 in dil. NaOH + NaSH (395); 495 in EtOH (505 with alkali) (429); 522.1 in EtOH with HCl and $SnCl_2$ (395); 461 in H_2SO_4 (454).

3′, 6′-Dihydroxyfluorescein: 493 (466).

$C_{20}H_{12}O_5S_2$.—Thiogallein: 526.2 in EtOH with HCl and $SnCl_2$; 582.3 in EtOH with NaOH and NaSH (395).

$C_{20}H_{15}N_2O_3(Cl)$.—Rhodamine chloride: *494*, 461.4 in H_2O; *500*, 468 in EtOH (155).

$C_{20}H_{16}O_5$.—4′-Methoxyresorcinolbenzein: 493 in alk. H_2O (466).

6′-Methoxyresorcinolbenzein: 492, 430 in alk. H_2O (466).

$C_{21}H_8Br_4Cl_2O_5$.—Phloxine methyl ester (K salt, C. I. 776): abs. in various solvents (3).

$C_{21}H_{10}Br_4O_5$.—Eosin methyl ester (K salt, C. I. 769): in H_2O, 517 at 20°, 519 at 80°; in EtOH, 529.9 at 20°, 531.4 at 70°; in $CHCl_3$, 538.2 at 20°, 539.3 at 60° (664).

$C_{21}H_{14}O_2$.—β, β-Dinaphthoxanthydrol: 508, 484 (473).

$C_{21}H_{14}O_6$.—3′-Methoxyfluorescein: 497 in alk. H_2O (466).

4′- (or 5′) Methoxyfluorescein: 492 in alk. H_2O (466).

$C_{21}H_{18}O_2$.—*o*-Cresolbenzein: 437, (347, 285), 278 in EtOH; *515*, 406, (297), 274 in EtOH + HCl; *581*, 385, 300, (250) in EtOH + KOH; *488*, 412, (297, 280), 261 in concd. H_2SO_4; 356, (296), *251* in concd. aq. KOH (495q).

$C_{21}H_{27}N_2O(Cl)$.—Tetraethyldiaminoxanthenyl chloride (C. I. 741): *553.9*, 514.4 in H_2O; *553.7*, 513.3 in EtOH; *553.7*, 513.3 in AmOH (155).

$C_{22}H_8Br_4Cl_4O_5$.—2, 4, 5, 7-Tetrabromo-3′, 4′, 5′, 6′-tetrachloro-γ-orcinolphthalein: *555*, (520) in alk. EtOH (486).

$C_{22}H_{12}Br_4O_5$.—Eosin ethyl ester (K salt, C. I. 770): 536.7 at 20°, 538.4 at 70° in EtOH (57).

2, 4, 5, 7-Tetrabromo-*α*-orcinolphthalein: 572 in alk. H_2O (486).

2, 4, 5, 7-Tetrabromo-*β*-orcinolphthalein: 576 in alk. EtOH (486); 307 in EtOH (287).

2, 4, 5, 7-Tetrabromo-*γ*-orcinolphthalein: 521 in alk. H_2O (466); 529 in alk. EtOH (486).

$C_{22}H_{12}Cl_4O_5$.—3′, 4′, 5′, 6′-Tetrachloro-*α*-orcinolphthalein: 562 in alk. H_2O (486).

3′, 4′, 5′, 6′-Tetrachloro-*β*-orcinolphthalein: 294 in EtOH (287); 554 in alk. EtOH (486).

3′, 4′, 5′, 6′-Tetrachloro-*γ*-orcinolphthalein: 511.5 in alk. H_2O (466); 521 in alk. EtOH (486).

$C_{22}H_{13}Br_3O_5$.—Tribromo-*β*-orcinolphthalein: 463 in alk. H_2O (466).

$C_{22}H_{14}Br_2O_5$.—4, 5-Dibromo-2, 7-dimethylfluorescein: 516 in alk. H_2O (466).

$C_{22}H_{16}O_5$.—2, 7-Dimethylfluorescein (Cresorcin): 500 in alk. H_2O (466).

α-Orcinolphthalein: 528 in alk. H_2O (486); *cf.* (197, 466).

β-Orcinolphthalein: 536 in alk. H_2O (486); *cf.* (156); 440 (466); 281 (287); 546 in alk. EtOH (156).

γ-Orcinolphthalein: *490.5*, 453 in alk. H_2O (156); *500.5*, 461 in alk. EtOH (156); *cf.* (466, 486).

$C_{22}H_{16}O_7$.—3′, 6′-Dimethoxyfluorescein: 499 in alk. H_2O (466).

4′, 5′-Dimethoxyfluorescein: 496 in alk. H_2O (466).

$C_{22}H_{19}N_2O_3(Cl)$.—*asym.*-Dimethylrhodamine chloride: *524*, 488.5 in H_2O; *526.7*, 489.2 in EtOH (*519.5*, 489.2 after standing) (155).

$C_{23}H_{18}O_8$.—3′, 4′, 5′-Trimethoxyfluorescein: 499 in alk. H_2O (466).

$C_{23}H_{20}NO_3(Cl)$.—Aporhodamine chloride: 530.7, 491.3, 459 in EtOH (155).

$C_{23}H_{23}N_2O(Cl)$.—Tetramethylrosamine chloride: *548.7*, 511.2 in H_2O; 551.9, 515.1 in EtOH (155); 555, 393, 360 in EtOH (44).

$C_{24}H_{20}O_3$.—Tetramethylfluoran: 480, 505 in concd. H_2SO_4 (476).

$C_{24}H_{20}O_5$.—3′, 6′-Dimethoxy-2, 7-dimethylfluoran: 585 in alk. soln. (195).

$C_{24}H_{23}N_2O_3(Cl)$.—Tetramethylrhodamine chloride: *546.7*, 509 in H_2O; *539.5*, 505.6 in EtOH (538.1, 501.6 after standing) (155).

sym.-Diethylrhodamine chloride: *519.3*, 487 in H_2O; 516.3, 483.7 in EtOH (155).

asym.-Diethylrhodamine chloride: *527.4*, 490.5 in H_2O, 527.4, 490.5 in EtOH (523.6, 490 after standing) (155).

$C_{25}H_{25}N_2O_3(Cl)$.—*asym.*-Diethylhomorhodamine chloride: *530.6*, 496.2 in H_2O; *527.3*, 492.7 in EtOH (155).

asym.-Dimethylhomorhodamine chloride ethyl ester (C. I. 753): *533.7*, 497.3 in H_2O; *531.3*, 494.8 in EtOH (155).

$C_{26}H_{27}N_2O_3(Cl)$.—*sym.*-Diethylrhodamine chloride ethyl ester (C. I. 752): *521.9*, 486.4 in H_2O; 524.7, 489.2 in H_2SO_4 (155); influence of concn. (269); in various solvents (3); in solid form (548); 530 on wool (642).

Triethylrhodamine chloride (C. I. 750): 353 in H_2O (352); 540 on wool (642).

$C_{27}H_{18}O_2$.—*C*-Phenyl-β, β-dinaphthoxanthydrol: 495, 470 (473).

$C_{27}H_{19}NO_4$.—Tetraethylrosamine chloride: 563.5, 527.5 in H_2O (523).

$C_{28}H_{10}Br_4O_7$.—2, 4, 5, 7-Tetrabromoanthraquinonefluorescein: NH_4 salt, 533 in H_2O; *539*, 500 in EtOH (649).

$C_{28}H_{12}Br_2O_7$.—4, 5-Dibromoanthraquinonefluorescein: NH_4 salt, 519 in H_2O; *525*, 491 in EtOH (649).

$C_{28}H_{14}O_7$.—Anthraquinonefluorescein: NH_4 salt, 506 in H_2O; *512*, 484 in H_2O (649).

$C_{28}H_{16}O_3$.—α-Naphthofluoran: 500, 475 in H_2SO_4 (467); 496, 470 in H_2SO_4 (473).

$C_{28}H_{16}O_5$.—α-Naphthofluorescein: *536.2*, 496 in alk. H_2O; *489.5*, 525, 459.5 in EtOH (*541.5*, 501 with alkali) (156); *cf.* (466).

$C_{28}H_{31}N_2O_3(Cl)$.—Tetraethylrhodamine chloride (Rhodamine B, C. I. 749): *552.6*, 514.6 in H_2O; *545.5*, 509.6 in EtOH (543.5, 505.6 after standing) (155); infra-red abs., *0.8*, (2.0), 3.0, 6.4, 7.3, 8.6, 8.9, (9.6), (11.0)μ (296); influence of concn. (269); dyeings (627, 642); *cf.* (3, 481, 519q, 666q, 676). Base: 545 in EtOH; 548 with band in the far violet in C_6H_6 (677).

$C_{30}H_{35}N_2O_3(Cl)$.—Tetraethylrhodamine chloride ethyl ester (C. I. 751): *555.5*, 516.3 in H_2O; *551.9*, 512.8 in EtOH (155); *560*, 525 on wool (522).

$C_{32}H_{22}N_2O_6S$.—Sulfodiphenyldiamino-*o*-carboxyphenylxanthenyl (Na salt, Violamine B, C. I. 757): 535 in H_2O (concd.); 545 (dil.) (269); 555 on wool (642).

$C_{34}H_{16}O_{10}$.—Difluorescein: 495 (111).

$C_{34}H_{26}N_2O_6S$.—Sulfodi-*o*-tolyldiamino-*o*-carboxyphenylxanthenyl (Na salt, Violamine R, C. I. 758): 361, *306* in H_2O (352); 540 on wool (642); influence of concn. (269).

$C_{34}H_{34}N_3O(Cl)$.—Acridylpyronine B: 580, 534.8 in H_2O (523).

$C_{34}H_{36}N_4O_2(Cl)_2$.—Dipyronine G: (668), 538 (111).

$C_{38}H_{34}N_2O_6S$.—Sulfodimesityldiamino-*o*-carboxyphenylxanthenyl (Violamine G, C. I. 759): 522.5 in H_2O; 535 on wool (642).

Table 6.—Quinoline Dyes

Note.—The 2, 2′-linkage is denoted by the term "pseudocyanine." When employed without further qualification the term "carbocyanine" also implies the 2, 2′-linkage.

$C_{13}H_{15}N_2$.—Dimethylprotocyanine (1, 1′-dimethyl-2-pyridylmethane): 428, 405 in H_2O (472).

$C_{17}H_{17}N_2$.—Dimethylmesocyanine: 495, 465, 430 in H_2O (472).

$C_{17}H_{19}N_2S(I)$.—2, 1′-Diethylthio-(pseudo)-pyridocyanine iodide: two poorly defined bands between 460 and 400 (449).

$C_{18}H_{11}NO_2$.—Quinoline yellow (C. I. 800): on wool (10); 440 in 50% EtOH; isopropyl deriv. and sulfonates (513).

$C_{19}H_{14}N_2$.—Di-(quinolyl-2)-methane: base, 508, *479*, 453 in EtOH (554).

$C_{19}H_{17}N_2O_2(I)$.—2, 2′-Dimethyloxacarbocyanine iodide (Oxazole Yellow): *485*, 456 in EtOH (346); (*485*, 460) (206).

$C_{19}H_{17}N_2S(I)$—1, 2′-Dimethylthiopseudocyanine iodide: 485, (460) (207).

$C_{19}H_{17}N_2S_2(Br)$.—1, 1′-Dimethylthiocarbocyanine bromide (Thiazole Purple): *558*, 526 in EtOH (346).

$C_{19}H_{19}N_2S_2(I)$.—2, 2′-Diethylthiocyanine iodide: *423*, 400 in EtOH (346); *cf.* (448).

$C_{20}H_{16}N_2$.—*N*-Methylquinolylenequinaldine: base, 461 in EtOH (554).

$C_{20}H_{18}N_3(I)$.—1, 1′-Dimethyl-2, 2′-azocyanine iodide: *424*, 402, 285 in EtOH (205); 421, 396 in H_2O; 375, 358 in concd. H_2SO_4 (472).

$C_{20}H_{19}N_2S(I)$.—2-Methyl-1′-ethylthiopseudocyanine iodide: *485*, (460) (207).

1′-Methyl-2-ethylthiopseudocyanine iodide: *485*, (460) (207).

$C_{20}H_{21}N_2(ClO_4)$.—*o*-Dimethylaminobenzylidenequinaldine methyl perchlorate: 455, 350 in EtOH (353 with HCl) (348).

p-Dimethylaminobenzylidenequinaldine methyl perchlorate: *515*, 338 in EtOH (350 with HCl) (348).

p-Dimethylaminobenzylidenelepidine methyl perchlorate: *526*, 293 in EtOH (348).

$C_{20}H_{21}N_2S_2(I)$.—5 (or 5′)-Methyl-2, 2′-diethylthiocyanine iodide: 427, 400 in EtOH (448).

$C_{20}H_{22}N_3(I)$.—*p*-Dimethylaminoanil of quinaldine aldehyde ethiodide: 568 (205).

$C_{21}H_{19}N_2(I)$.—1, 1′-Dimethylpseudocyanine iodide: *523*, 488, 455 in EtOH; 317 with H_2SO_4 (340); *cf.* (150, 317).

1, 1′-Dimethylisocyanine iodide: 558, 519 in EtOH (446); *cf.* (122, 202, 667); perchlorate, 545, 500, 286 in EtOH (317 with HCl) (348).

$C_{21}H_{20}N_3(I)$.—5-Amino-1, 1′-dimethylisocyanine iodide: 555, 520 in EtOH (202).

6-Amino-1, 1′-dimethylisocyanine iodide: 575, 535 in EtOH (202).

7-Amino-1, 1′-dimethylisocyanine iodide: 570, 535 in EtOH (202).

6′-Amino-1, 1′-dimethylisocyanine iodide: 570, 535 in EtOH (202).

7′-Amino-1, 1′-dimethylisocyanine iodide: 545, 510 in EtOH (202).

$C_{21}H_{21}N_2O_2(I)$.—2, 2′-Diethyloxacarbocyanine iodide: 485, 460 in EtOH (206).

1′, 6′-Dimethyl-2-ethylthioisocyanine iodide: 500, 487 in EtOH (56).

2, 1′-Diethylthioisocyanine iodide: 503, 489 in EtOH (155).

$C_{21}H_{21}N_2S(I)$.—2, 1′-Diethylthiopseudocyanine iodide: *493*, 461 (449); *485*, (460) (207).

$C_{21}H_{21}N_2S_2(I)$.—2, 2′-Diethylcarbothiocyanine iodide: 559, 525 in EtOH (448).

$C_{21}H_{23}N_2(I)$.—*p*-Dimethylaminobenzylidenequinaldine ethiodide: 532 (205).

$C_{22}H_{21}N_2(I)$.—1-Methyl-1′-ethylisocyanine iodide: 558, 519 in EtOH (446).

1, 6, 1′-Trimethylisocyanine iodide (Pinaverdol, C. I. 807): 558 in EtOH (667); *cf.* (361q, 668q).

1, 1′, 6′-Trimethylisocyanine iodide: 558 in EtOH (667).

$C_{22}H_{23}N_2(ClO_4)$.—*p*-Dimethylaminocinnamylidenequinaldine methyl perchlorate: *523*, 341 in EtOH (405 with HCl) (348).

$C_{22}H_{23}N_2(I)$.—1, 3, 3, 1′-Tetramethylindopseudocyanine iodide: 470 in EtOH (207).

$C_{22}H_{23}N_2S(I)$.—5, 1′, 6′-Trimethyl-2-ethylthioisocyanine iodide: 507, 495 in EtOH (56).

5-Methyl-2, 1′-diethylthioisocyanine iodide: 508, 492 in EtOH (56).

$C_{23}H_{13}NO_5$.—Resorcinolquinolineine: 490 in alk. H_2O (467).

$C_{23}H_{15}NO_4$.—Phenolquinolineine: 533 in alk. H_2O (467).

$C_{23}H_{21}N_2(I)$.—1, 1′-Dimethyl-2, 2′-carbocyanine iodide: *607*, 561, 521 in EtOH (331 with H_2SO_4) (340); *cf.* (203, 346, 667).

1, 1′-Dimethyl-4, 4′-carbocyanine iodide: 715 in EtOH (206).

$C_{23}H_{21}N_2S_2(Br)$.—2, 2′-Diallylcarbothiocyanine bromide: *560*, 522 in EtOH (206).

$C_{23}H_{22}N_3O(I)$.—5-Acetylamino-1, 1′-dimethylisocyanine iodide: 560, 525 in EtOH (202).

6-Acetylamino-1, 1′-dimethylisocyanine iodide: 570, 530 in EtOH (202).

7-Acetylamino-1, 1′-dimethylisocyanine iodide: 565, 530 in EtOH (202).

6′-Acetylamino-1, 1′-dimethylisocyanine iodide: 565, 530 in EtOH (202).

7′-Acetylamino-1, 1′-dimethylisocyanine iodide: 555, 525 in EtOH (202).

$C_{23}H_{23}N_2(I)$.—1, 6, 1′, 6′-Tetramethylisocyanine iodide: 562 in EtOH (667).

1, 6-Dimethyl-1′-ethylisocyanine iodide: 560 in EtOH (667).

1, 1′-Diethylisocyanine iodide (Ethyl Red, C. I. 807): *558*, 517 in EtOH (446); *cf.* (301).

1, 6, 1′, 6′-Tetramethylpseudocyanine iodide: *522*, 490 in EtOH (207).

1, 1′-Diethylpseudocyanine iodide: *525*, 490 in EtOH (207); *cf.* (555).

$C_{23}H_{25}N_2(Br)$.—"Rosol red bromide:" *526*, 492, 276 in MeOH (342).

$C_{23}H_{25}N_2OS(I)$.—6′-Ethoxy-2, 1′-diethylthioisocyanine iodide: 506, 493 in EtOH (56).

$C_{24}H_{24}ClN_2(I)$.—6-Methyl-6′-chloro-1, 1′-diethylisocyanine iodide: *575*, 540 in EtOH (587).

6-Chloro-6′-methyl-1, 1′-diethylisocyanine iodide: 575, 547 in EtOH (587).

$C_{24}H_{24}N_3(I)$.—*p*-Dimethylaminoanil of β-naphthoquinaldine aldehyde ethiodide: 560 in EtOH (205).

$C_{24}H_{25}N_2(I)$.—2′-Methyl-1, 1′-diethylisocyanine iodide: *559*, 518 (301).

7-Methyl-1, 1′-diethylisocyanine iodide: 570, 535 in EtOH (587).

6 (or 6′)-Methyl-1, 1′-diethylpseudocyanine iodide: *530*, 495 in EtOH (207).

$C_{23}H_{25}N_2S_2(I)$.—5, 5′-Dimethyl-2, 2′-diethylthiocarbocyanine iodide: 563, 529 in EtOH (448).

$C_{24}H_{27}N_2(I)$.—3, 3-Dimethyl-1, 1′-diethylindopseudocyanine iodide: 480 in EtOH (207).

$C_{24}H_{27}N_2OS(I)$.—6′-Ethoxy-5-methyl-2, 1′-diethylthioisocyanine iodide: 511, 499 in EtOH (56).

$C_{25}H_{17}NO_5$.—Orcinolquinolineine: 496 in alk. H_2O (467).

$C_{25}H_{19}NO_5$.—*o*-Cresolquinolineine: 544 in alk. H_2O (467).

$C_{25}H_{21}N_2(I)$.—1, 1′-Dimethyl-5, 6 (or 5′, 6′)-benzopseudocyanine iodide: *538*, 500 in EtOH (207).

$C_{25}H_{25}N_2(I)$.—*p*-Dimethylaminobenzylidene-β-naphthoquinaldine ethiodide: 525 in EtOH (205).

1, 6, 1′, 6′-Tetramethyl-2, 2′-carbocyanine iodide: 570, 530 in EtOH (202).

1, 1′-Diethylcarbocyanine iodide (Pinacyanol, C. I. 808): infra-red abs. (387); *607*, 562.5, 519.2 in EtOH (451); *cf.* (149, 203, 340, 362q, 363q, 450q, 668q).

1, 4, 1′, 2′-Tetramethyl-2, 4′-carbocyanine iodide: 653, 606 (667).

1, 1′-Diethyl-2, 4′-carbocyanine iodide: 657, 606.5 in EtOH (450q).

1, 1′-Diethyl-4, 4′-carbocyanine iodide (Kryptocyanine, C. I. 810): 711.5, 655 in EtOH (450q); *cf.* (449).

$C_{25}H_{27}Cl_2N_2(I)$.—5, 5′-Dichloro-1, 3, 3, 1′, 3′, 3′-hexamethylindocarbocyanine iodide: *551*, 517, (489) in MeOH (342).

$C_{25}H_{27}N_2(I)$.—1, 1′-Diethyl-6, 6′-dimethylisocyanine iodide (Orthochrome T, C. I. 807): 520 in alk. H_2O (concd.); 570 (dil.) (269); *cf.* (362).

Propylisocyanine: *563*, 522 in EtOH (446).

$C_{25}H_{27}N_2O(I)$.—1, 1′-Diethyl-6-methoxy-6′-methylisocyanine iodide: *580*, 540 in EtOH (587).

1, 1′-Diethyl-6-methyl-6′-methoxyisocyanine iodide: *575*, 540 in EtOH (587).

1, 1′-Diethyl-6′-ethoxyisocyanine iodide: *575*, 540 in EtOH (587).

$C_{25}H_{27}N_2O_2(I)$.—1, 1′-Diethyl-6, 6′-dimethoxyisocyanine iodide: *585*, 560 in EtOH (587).

$C_{25}H_{27}N_4(I)$.—1, 1′-Diethyl-6, 6′-diaminocarbocyanine iodide: 640, 595 in EtOH (204).

$C_{25}H_{29}N_2(I)$.—1, 3, 3, 1′, 3′, 3′-Hexamethylindocarbocyanine iodide (Indolenine Red): *548*, 512 in EtOH (206); *cf.* (346); *546*, 512, (483), 281 in MeOH (342).

$C_{26}H_{19}N_2(Cl)$.—1, 1′-Benzylidene-2, 2′-quinocyanine chloride (Quinoline Red, C. I. 805): 536, 499 (78).

$C_{26}H_{29}N_2(I)$.—Methylhexylisocyanine iodide: *560*, 519 in EtOH (446).

$C_{26}H_{29}N_2O(I)$.—1, 1′-Diethyl-6-methyl-6′-ethoxyisocyanine iodide: *575*, 545 in EtOH; 580 in $CHCl_3$ or C_7H_8; 590 in C_9H_7N (587); bromide, 575, 535 in H_2O; *577*, 535 in EtOH; *583*, 540 in $CHCl_3$ (influence of temp. given) (588).

1, 1′-Diethyl-6-ethoxy-6′-methylisocyanine iodide: *580*, 545 in EtOH (587).

$C_{26}H_{29}N_2O_2(I)$.—1, 1′-Diethyl-6-ethoxy-6′-methoxyisocyanine iodide (Pinachrome, C. I. 807): 530 in alk. H_2O (concd.); 575 (dil.); 580 in EtOH (95%) (269); 535 in H_2O; *650*, 595 in EtOH (588); *cf.* (361q).

$C_{27}H_{25}N_2(I)$.—1, 1′-Diallyl-4, 4′-carbocyanine iodide; 715 in EtOH (206).

1, 1′-Diethyl-5, 6 (or 5′, 6′)-benzopseudocyanine iodide: *538*, 500 in EtOH (207).

Diethylbenzoisocyanine iodide (?): *580*, 548 in EtOH (341).

$C_{27}H_{29}N_2(Br)$.—1, 1′-Diethyl-4, 4′-dimethyl-2, 2′-carbocyanine bromide (Fischer's α-Pseudodicyanine): *606*, 559 in EtOH (316).

$C_{27}H_{29}N_2(Cl)$.—1, 1′-Diethyl-6, 6′-dimethyl-2, 2′-carbocyanine chloride: *613*, 566 in EtOH (316).

$C_{27}H_{29}N_2(I)$.—1, 1′-Diethyl-2′, 4-dimethyl-2, 4′-carbocyanine iodide (Fischer's α-Dicyanine): *655.5*, 603.5 in EtOH (450q); *cf.* (149, 667).

$C_{27}H_{33}N_2(I)$.—3, 3, 3′, 3′-Tetramethyl-1, 1′-diethylindocarbocyanine iodide: *548*, 512 in EtOH (206).

$C_{28}H_{19}N_3$.—*sym.*-Triquinolyl-2-methane: 523, 487 in EtOH (556).

$C_{28}H_{25}N_2(I)$.—1-Ethyl-1′-methyl-2′-phenylisocyanine iodide: *565*, 525 in H_2O or EtOH (301).

$C_{28}H_{27}N_2(I)$.—1, 1′-Diethyl-6′-methyl-5, 6-benzoisocyanine iodide (?): *585*, 550 in EtOH (341).

$C_{29}H_{27}N_2(Br)$.—1, 1′-Diethyl-5, 6-benzocarbocyanine bromide: 625, 575, 535 in EtOH (451).

$C_{29}H_{29}N_2(I)$.—6, 6′-Dimethyl-1, 1′-diallyl-2, 2′-carbocyanine iodide: *620*, 570 in EtOH (206).

$C_{29}H_{31}N_4O_2(I)$.—1, 1′-Diethyl-6, 6′-diacetylaminocarbocyanine iodide: 625, 575 in EtOH (204).

$C_{29}H_{33}N_2(I)$.—1, 1′-Diethyl-4, 6, 4′, 6′-tetramethyl-2, 2′-carbocyanine iodide (Fischer's "Pseudodicyanine Iodide"): *611*, 565 in EtOH (316).

$C_{29}H_{33}N_2(Br)$.—1, 1′-Diethyl-4, 6, 2′, 6′-tetramethyl-2, 4′-carbocyanine bromide (Fischer's "Dicyanine Bromide"): *662*, 610 in EtOH (317).

$C_{29}H_{33}N_2O_2(I)$.—1, 1′-Diethyl-5, 5′-diethoxycarbocyanine iodide: 603, 559 in EtOH (55).

1, 1′-Diethyl-6, 6′-diethoxycarbocyanine iodide: 622, 576 in EtOH (55).

1, 1′-Diethyl-7, 7′-diethoxycarbocyanine iodide: 617, 571 in EtOH (55).

$C_{29}H_{35}N_2(I)$.—1, 1′-Diisoamylcyanine iodide (Cyanine, C. I. 806): infra-red abs., 0.7, 3.3, (5.1), *6.6*, *7.5*, *8.5*, 9.5, 10.4μ (296); *cf.* (80, 510, 511); 586, 550 in H_2O; 595, 552 in EtOH (3); *cf.* (114q, 361q, 362q, 528q); influence of temp. (334, 363q).

$C_{29}H_{35}N_2O_2(I)$.—1, 1′-Diethyl-2, 2′-dimethyl-6, 6′-diethoxycyanine iodide: 620 in EtOH (500).

$C_{30}H_{26}N_3O(I)$.—5-Cinnamoylamino-1, 1′-dimethylisocyanine iodide: 560, 525 in EtOH (202).

6-Cinnamoylamino-1, 1′-dimethylisocyanine iodide: 575, 535 in EtOH (202).

6′-Cinnamoylamino-1, 1′-dimethylisocyanine iodide: 570, 530 in EtOH (202).

7′-Cinnamoylamino-1, 1′-dimethylisocyanine iodide: 560, 520 in EtOH (202).

$C_{31}H_{31}NO_4$.—Thymolquinolineine: 593 in alk. soln. (467).

$C_{31}H_{37}N_2O_2(I)$.—1, 1′-Diethyl-4, 2′-dimethyl-6, 6′-diethoxy-2, 4′-carbocyanine iodide (Dicyanine A, C. I. 811): 672 in EtOH (500); band at 1.4μ (387).

$C_{33}H_{27}N_2(I)$.—4, 4′-Diphenyl-1, 1′-dimethylpseudocyanine iodide: *541*, 501 (150).

$C_{33}H_{27}N_2(Br)$.—5, 6, 5′, 6′-Dibenzo-1, 1′-diethylcarbocyanine bromide: 638, 588, 550 in EtOH (451).

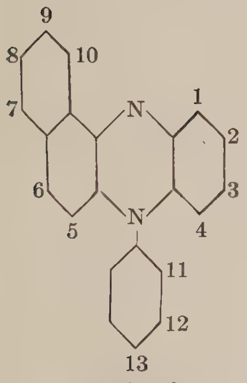
$C_{35}H_{29}N_2(I)$.—4, 4′-Diphenyl-1, 1′-diethylcarbocyanine iodide: *624*, 576 in EtOH (149).

$C_{35}H_{33}N_2(I)$.—4, 4′-Diphenyl-1, 6, 1′, 6′-tetramethylpseudocyanine iodide: *547*, 507 in EtOH (150).

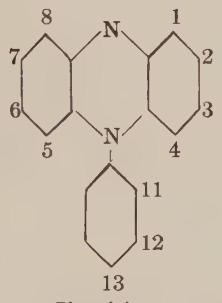
$C_{37}H_{33}N_2(I)$.—4, 4′-Diphenyl-1, 6, 1′, 6′-tetramethylcarbocyanine iodide: *631*, 581 in EtOH (149).

$C_{44}H_{44}ClN_4O_6(I)$.—4′-Chloro-3, 3′-di-(*o*-carbethoxyphenylmethylcarbamyl)-1, 2, 1′-trimethylisocyanine iodide: 574, 325 (250).

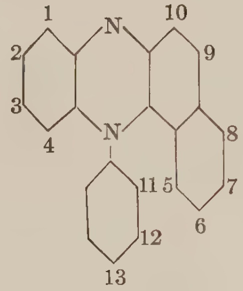
Table 7.—Azine Derivatives



Phenylnaptho-phenazine



Phenylphena-zine



Phenylisonaphtho-phenazine

$C_{12}H_8N_2$.—Phenazine: 355 in EtOH (217); *cf.* (111, 317); 360, (240) in Et_2O (309); monacid salt, 450, 385, 255 (309); *cf.* (317); diacid salt, 552, 506, 395, 265 (317); *cf.* (309, 316).

$C_{12}H_8N_2O_2$.—3, 6-Dihydroxyphenazine: 510 (465).

$C_{12}H_9N_3$.—3-Aminophenazine: 472, 265 in EtOH (317); 468, 365, 265 in Et_2O (309); monacid salt, 557, 516, 385, 285, 255 in H_2O (309); *cf.* (155); 557, *516.8*, 483 in EtOH (155); 385, 280 (317); diacid salt, 750 in HCl; triacid salt, 541, 506 in H_2SO_4 (317); *cf.* (309).

$C_{12}H_{10}N_4$.—2, 3-Diaminophenazine: 454, 285, 265 in EtOH (317); chloride, 483.7, *455.5*, 433.8 in EtOH (155); 285 (317); diacid salt, *505*, 463 in EtOH; triacid salt, 505 in H_2SO_4; tetraacid salt (598), (489) in fuming H_2SO_4 (317).

$C_{12}H_{10}N_4$.—3, 6-Diaminophenazine: 447, 265 in EtOH (317); chloride, 513, 491.5 in H_2O (155); *521.7*, 490 in EtOH (155); 280 (317); diacid salt, 580 in EtOH; polyacidic salts (317).

$C_{12}H_{10}N_4$.—Aminophenylphentriazine: 310 in EtOH + HCl (377).

$C_{13}H_{10}N_4O_4$.—1, 3-Dinitromethyldihydrophenazine: 581, 538 (304).

$C_{13}H_{11}N_2$.—*N*-Methylphenazine: monacid salt, 390, 260 in acid EtOH; diacid salts, 560, 510, 400, 265 in H_2SO_4 (316); *cf.* (309); holo- and meriquinoid salts (217).

$C_{13}H_{11}N_3$.—3-Aminomethylphenazine: 530, *505*, 490 in Et_2O; monacid salt, 562, *525*, (494), 385, 285 in EtOH; diacid salt, 674.5, 610, 459 in H_2SO_4; triacid salt, 520, 490 in fuming H_2SO_4 (319); *cf.* (308, 309).

$C_{13}H_{13}N_4(ClO_4)$.—3, 6-Diaminomethylphenazine perchlorate: *530*, 483 in EtOH (320); *cf.* (318).

$C_{15}H_{13}N_4(Cl)$.—Cyantrypaflavine: *538*, 501, 275 in EtOH (221).

$C_{16}H_{19}N_4(Cl)$.—3, 5-Tetramethyldiaminophenazonium chloride: 510 in H_2O (465).

$C_{17}H_{21}N_4(Cl)$.—3, 5-Tetramethyldiaminomethylphenazonium chloride: 567, 280, 265 in EtOH (182).

$C_{18}H_{10}N_4$.—Phenazineazine: 431 (111).

$C_{18}H_{12}Cl_2N_2(Cl)$.—3, 6-Dichlorophenylphenazonium chloride: 411, 269 in EtOH (23).

$C_{18}H_{12}N_2O_2$.—Hydroxyaposafranone: 488, 268 in dil. NaOH soln.; 479, 270 in dil. HCl (23).

$C_{18}H_{13}N_2$.—Phenylphenazine: monacid salt, 395, 265 in EtOH; diacid salt, 570, 525, 416, 270 in H_2SO_4 (316); *cf.* (309).

$C_{18}H_{13}N_3$.—1-Aminophenylphenazine: monacid salt, 487, *390*, 310, 240 (nitrate in EtOH) (319); *cf.* (245); diacid salt, 390, 263 in H_2SO_4; triacid salt, *603*, 485 in 100% H_2SO_4 (319); *cf.* (309).

2-Aminophenylphenazine: monacid salt, 582 in EtOH; diacid salt, 400, 288 in EtOH + H_2SO_4; triacid salt, 575, 470 in H_2SO_4 (319).

3-Aminophenylphenazine (Aposafranine): 555, *512*, 483 in EtOH (319); 290 (309); monacid salt, 563, *519*, 483, 390, 285 in EtOH; diacid salt, 694, 625, 570, (465), 420, 285 in 60% H_2SO_4; triacid salt, 580, 520, 490, 420, 270 in H_2SO_4 (319); *cf.* (155, 309, 324).

$C_{18}H_{15}N_3$.—Dimethylnaphtheurhodine: 482 in EtOH (or $CHCl_3$) (377).

$C_{18}H_{15}N_4(ClO_4)$.—1, 3-Diaminophenylphenazine perchlorate: 585, 463, 431, 295 in EtOH; diacid salt, 564, 530, 490, 395, 285 in EtOH + H_2SO_4; triacid salt, 483 in H_2SO_4; tetraacid salt, 530 in fuming H_2SO_4 (320); *cf.* (308, 309).

2, 6-Diaminophenylphenazine perchlorate: 640, 605, 330, 295 in EtOH; diacid salt, 565, 528, 483, 390, 285 in EtOH + H_2SO_4; triacid salt, 610, (583), 410, 295 in H_2SO_4 (320); *cf.* (309).

$C_{18}H_{15}N_4(Cl)$.—2, 13-Diaminophenylphenazine chloride: monacid salt (460), 400, 297, 265 in acid EtOH; abs. of diacid salt indefinite; triacid salt, 563, 518, 410, 275 in concd. H_2SO_4 (309).

3, 6-Diaminophenylphenazine chloride (Phenosafranine, C. I. 840): 525, 494 in H_2O (155); *534*, 501, 270 in EtOH; diacid salt (645), 586, 400, 290 in acid EtOH; triacid salt, (583) in H_2SO_4; tetraacid salt, 570 in fuming H_2SO_4 (320); influence of concn. (269); *cf.* (23, 35q, 221, 308, 309, 467). Phenosafranineazodimethylaniline, 579; phenosafraninedisazo-*bis*-dimethylaniline: 513 (111).

3, 7-Diaminophenylphenazine chloride: diacid salt, 567, 530 in acid EtOH (308).

3, 11-Diaminophenylphenazine chloride: 572, *535*, 490 in EtOH; diacid salt, 565, 525 in acid EtOH (308); *cf.* (246).

3, 13-Diaminophenylphenazine chloride: 572, 535, 490, 395, 285 in H_2O; diacid salt, 565, 525, 490, 400, 286 in dil. H_2SO_4 (309); *cf.* (35).

$C_{19}H_{15}N_3$.—3-Phenylaminomethylphenazine: 525 in Et_2O; monacid salt, 565, 410, 285 in EtOH; diacid salt, 478 in H_2SO_4 (319).

$C_{20}H_{15}N_3O$.—2-Acetylaminophenylphenazine: monacid salt, 500, 400, 285 in EtOH; diacid salt, 570, 515, (470) in H_2SO_4 (319)

$C_{20}H_{16}N_3O$.—3-Acetylaminophenylphenazine: 564, *530*, 499 in EtOH; monacid salt, 508, (489), (472), 410, 285 in EtOH; diacid salt, 579, 520, 441, 415 in H_2SO_4 (319); *cf.* (309).

$C_{20}H_{17}N_4O(Cl)$.—1-Acetylamino-3-aminophenylphenazine chloride: 590, 548 in EtOH (320).

2-Acetylamino-6-aminophenylphenazine chloride: *582*, 543 in EtOH (320).

$C_{20}H_{19}N_4(Cl)$.—*asym.*-Dimethylphenosafranine chloride (C. I. 842): 550, 526.5 in H_2O; *551.9*, 511.5 in EtOH; 555, 514.4 in AmOH (155).

Ethylphenosafranine chloride: *537.5*, 502.4 in H_2O; *539.3*, 500 in EtOH; *543*, 503 in AmOH (155).

$C_{21}H_{21}N_4(Cl)$.—Diamino-*o*-tolylditolazine chloride (with phenyl isomer, commercial Safranine, C. I. 841): 495 in H_2O (concd.); 515 (dil.) (269); ultra-violet abs. and influence of acidity (388); on silk (10, 627); *535*, 515 on wool (522); *cf.* (162q, 391). Safranineazodimethylaniline (C. I. 133): infra-red abs. (511). Safranineazo-β-naphthol (C. I. 135): 600 on cotton, 608.5 with tannin mordant (627).

$C_{22}H_{15}N_2$.—Phenylnaphthophenazine: monacid salt, 480, 290; diacid salt, 524, *513*, 484, 303 (321); *cf.* (324).

Phenylisonaphthophenazine: monacid salt (475), 415, 292 in H_2O (325); 496 in EtOH (322); diacid salt, 632, 598, 503, 310 in H_2SO_4 (325); *cf.* (322).

$C_{22}H_{15}N_3$.—2-Aminophenylnaphthophenazine: monacid salt, 545, (490), 440, 312, 290; diacid salt, 290; triacid salt, *510*, 485, 305 (321); *cf.* (324).

2-Aminophenylisonaphthophenazine: 580, 560, *465*, perchlorate in EtOH; diacid salt, 490 in 50% H_2SO_4; triacid salt, 590, *506*, 450 in fuming H_2SO_4 (322); *cf.* (325).

3-Aminophenylnaphthophenazine (Isorosinduline): 575, 531, 493 in Et_2O; monacid salt, 565, *533*, 425, 310, 282, 265; diacid salt, 690, 481, 285; triacid salt, 529, *517*, 485, 302 (321); *cf.* (324).

3-Aminophenylisonaphthophenazine: monacid salt, 581, 540, 499; diacid salt, 430 in 50% H_2SO_4; triacid salt, 590, *505*, 450 in fuming H_2SO_4 (322); *cf.* (325).

6-Aminophenylnaphthophenazine (Rosinduline): 599, 556, 516, 483 in Et_2O; monacid salt, 533, *501*, 472, 313; diacid salt, *668*, 605, 555, (453), 335; triacid salt, 530, *512*, 490 (321); *cf.* (324).

6-Aminophenylisonaphthophenazine: monacid salt, 581, 545, (425), 335, 270 in H_2O; diacid salt, 395, 293 in 30% H_2SO_4; triacid salt, 586, 539, 482, 303 in concd. H_2SO_4 (325); *cf.* (322).

7-Aminophenylnaphthophenazine: monacid salt (577), 350, 277; diacid salt, 288; triacid salt, 583, *500*, 302 (321); *cf.* (324).

7-Aminophenylisonaphthophenazine: monacid salt, 580, 544, 335, 285 in H_2O; diacid salt, 462, 296 in 35% H_2SO_4; triacid salt, 583, 535, 485, 305 in concd. H_2SO_4 (325); *cf.* (322).

8-Aminophenylnaphthophenazine: monacid salt, (486), *456*, 333, 285; diacid salt 290; triacid salt, 577, *496*, 460, 304 (321); *cf.* (324).

8-Aminophenylisonaphthophenazine: monacid salt, 586, 547, 457, (362), 332, 272 in H_2O; diacid salt (475), 400, 290 in 30% H_2SO_4; triacid salt, 584, 536, 482, 303 in concd. H_2SO_4 (325); *cf.* (322).

9-Aminophenylnaphthophenazine: monacid salt, *585*, 480, 442, 335; diacid salt, 287; triacid salt, 579, *495*, 460, 288 (321); *cf.* (324).

9-Aminophenylisonaphthophenazine: monacid salt, 585, 553, 408, 325 in H_2O; diacid salt, 580, 458, 333, in 50% H_2SO_4; triacid salt, 583, 532, 508, 450, 310 in H_2SO_4 (325); *cf.* (322).

10-Aminophenylnaphthophenazine: monacid salt, (465), 290; diacid salt, 290 (321); *cf.* (324).

10-Aminophenylisonaphthophenazine: chloride in H_2O, 420, 335, 260 (245); diacid salt, 489, (450) in dil. H_2SO_4; triacid salt, 585, 535, 490 (322).

12-Aminophenylnaphthophenazine: monacid salt, 287; diacid salt, 290; triacid salt, (645, 593), (*520*, 488, 452), 310 (321); *cf.* (324).

13-Aminophenylnaphthophenazine: monacid salt, 287; diacid salt, 290; triacid salt, (590), (*528*, 492), (540), (310) (321); *cf.* (324).

13-Aminophenylisonaphthophenazine: perchlorate in EtOH, 475; diacid salt, 488 in 10% H_2SO_4; triacid salt, 590, 500, (470?), 450 in concd. H_2SO_4 (322).

$C_{22}H_{19}N_4O_2(Cl)$.—1, 3-Di-(acetylamino)-phenylphenazine chloride: 580, 505 in EtOH (320).

2, 6-Di-(acetylamino)-phenylphenazine chloride: *545*, 504 in EtOH (320).

$C_{22}H_{23}N_4(Cl)$.—*asym.*-Diethylphenosafranine chloride: 561.8, 531.2 in H_2O; *556.1*, 569.3 in EtOH; *558.5*, 517.5 in AmOH (155).

$C_{24}H_{12}N_6$.—Phenazineazineazine: 432 (111).

$C_{24}H_{17}ClN_3(Cl)$.—3-Chloro-6-phenylaminophenylphenazine: 545, 405, 316 (23).

$C_{24}H_{18}N_3$.—3-Phenylaminophenylphenazine: 516 in Et_2O; monacid salt, 569.3, 400, 285 in EtOH; diacid salt, 490 in H_2SO_4 (319).

$C_{24}H_{18}N_4$.—2, 3-Di-(phenylamino)-phenazine: 480, 285 in EtOH; monacid salt, 508, 285 in EtOH; diacid salt, 542 (317).

$C_{24}H_{19}N_4(Cl)$.—Phenylphenosafranine chloride: 547 in H_2O; 556 in EtOH; 561 in AmOH (155).

$C_{24}H_{30}N_3(Cl)$.—Dimethylisorosinduline chloride (Neutral Blue, C. I. 832): infra-red abs. (296).

$C_{25}H_{21}N_4(ClO_4)$.—3, 6-Di-(phenylamino)-methylphenazine perchlorate: 572 in EtOH (320).

$C_{26}H_{22}N_4$.—3, 6-Di-(tolylamino)-phenazine: 494, 285 in EtOH; monacid salt, 572, 285 in EtOH; polyacidic salts (317). Indazine M: 598.5 on cotton; 610 with tannin mordant (627).

$C_{26}H_{31}N_4(Cl)$.—Tetraethylphenosafranine chloride (C. I. 847): *589*, 548.9 in H_2O; *578.7*, 534.8 in EtOH; *580.2*, 535.7 in AmOH (155); *579*, 535, 285 in EtOH (221); perchlorate in EtOH, *595*, 545 (320).

$C_{27}H_{25}N_4(ClO_4)$.—3, 6-Di-(*p*-tolylamino)-methylphenazine perchlorate: 580 in EtOH (320).

Aminophenylamino-*p*-tolylditolazonium salts (and homologs) C. I. 846: Aniline violet, various salts (497).

$C_{28}H_{19}ClN_3(NO_3)$.—3-Chloro-6-α-naphthylaminophenylphenazine nitrate: 549, 390, 303 (23).

$C_{30}H_{20}N_3Cl$.—Aminonaphthyldinaphthazine and diamino isomer (Magdala Red, C. I. 857): 570 in EtOH; 575 in $C_6H_5NH_2$ (299q).

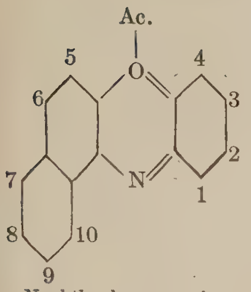
$C_{30}H_{23}N_4(Cl)$.—*sym.*-Diphenylphenosafranine chloride: 570.7 in H_2O; 580.7 in EtOH; 585.7 in AmOH (155).

$C_{34}H_{24}ClN_4(NO_3)$.—3-Chloro-7-phenylamino-6-naphthylaminophenylphenazine nitrate: 561, 303 (23).

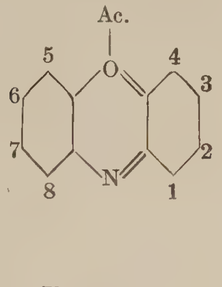
$C_{34}H_{25}N_4(NO_3)$.—3-Phenylamino-6-α-naphthylaminophenylphenazine nitrate: 561, 302 (23).

Fast Blue: influence of concn. (299). Induline dyes: (65). Nigrosine SS: infra-red abs. (387). Rhoduline Blue R: 550 in H_2O (concd.), 565 (dil.) (269). Rhoduline Red B (C. I. 844): 510 in H_2O (concd.), 533 (dil.) (269). Azine and eurhodol dyes obtained from the reduction products of azo dyes (123).

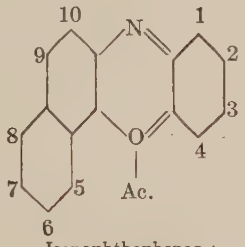
TABLE 8.—OXAZINE DERIVATIVES



Naphthophenazoxonium salts



Phenazoxonium salts



Isonaphthophenazoxonium salts

$C_{12}H_2Br_4NO_3(NH_4)$.—Tetrabromoresorufin, NH_4 salt (C. I. 908): (481).

$C_{12}H_5N_5O_9$.—1, 3, 5, 7-Tetranitrophenazoxine: (304).

1, 3, 6, 7-Tetranitrophenazoxine: 642 in alk. EtOH (304).

1, 3, 6, 8-Tetranitrophenazoxine: 632 in alk. EtOH (304).

$C_{12}H_6N_4O_7$.—1, 3, 6-Trinitrophenazoxine: 639 in alk. EtOH (304).

1, 3, 7-Trinitrophenazoxine: 505 in alk. EtOH (304).

$C_{12}H_7N_2O_3$.—Resorufin: *568*, 422 in EtOH (648); K salt, *573.6*, 554.8, 530.8 in H_2O; 588.5, *578.8*, 559.4, 540.1 in EtOH; 592.4, *580.5*, 561.2, 543.5 in AmOH (155); *cf.* (465, 497).

$C_{12}H_7NO_4$.—Resazurin: Na salt, 601, 555.9 in H_2O; *610.2*, 587.5 in EtOH; 629.8, *612*, 592.5, 574, 559.6 in AmOH (155); *cf.* (497).

$C_{12}H_7N_3O_5$.—1, 3-Dinitrophenazoxine: 534, 502 in EtOH (304).

3, 6-Dinitrophenazoxine: 704 in alk. EtOH (304).

$C_{12}H_8NO$.—Phenazoxonium salts: monoacid, 505 (312); 410, 313 (309); diacid, 460 (in $H_2SO_4 + H_2O_2$) (312).

$C_{12}H_8N_2O_3$.—3-Nitrophenazoxine: 678, 618, 572 in alk. EtOH (304).

$C_{12}H_8N_2O_2$.—Resorufamine: *577.7*, 533.9 in H_2O; *578.7*, 535.7 in EtOH; *580.2*, 536.6 in AmOH (155).

$C_{12}H_9N_2O$.—1-Aminophenazoxonium salts: monacid, 400, 285, 265; diacid, 535, (480), 430, 265 (in H_2SO_4) (312); *cf.* (309).

3-Aminophenazoxonium salts: monacid, 492, 285, *265*; diacid, 640, 590, 285, *265* (312); *cf.* (309).

$C_{12}H_{10}N_3O$.—1, 3-Diaminophenazoxonium salts: monacid, (440) in dil. H_2SO_4; diacid (568), 529, 265 in 50% H_2SO_4 (309).

3, 6-Diaminophenazoxonium salts: chloride, *586.8*, 541.5 in H_2O; *593*, 574.5, 545.1 in EtOH; *598.3*, 579.5, 549.5 in AmOH (155); bands at (410) in H_2O (309) and at 285, 265 in EtOH (313); triacid salt, 522 (with fuming H_2SO_4) (309).

$C_{14}H_{12}N_2O_2$.—Dimethylresorufamine: *591.7*, 545.5 in H_2O; *580*, 538.5 in EtOH; 576.2, 535.7 in AmOH (155).

$C_{14}H_{12}NO$.—3, 6-Dimethylphenazoxonium salts: monacid, 560, (460); diacid, 500 (in H_2SO_4) (312); *cf.* (309).

$C_{14}H_{14}N_3O(Cl)$.—*asym.*-3, 6-Dimethyldiaminophenazoxonium chloride: *619.5*, 570 in H_2O; 616, 597.1, 566.8 in EtOH; *618*, 598.5, 568.2 in AmOH (155).

$C_{15}H_{12}N_2O_5$.—Dimethylaminohydroxycarboxydiphenoxazone (C. I. 883): Gallocyanine W, 520 in H_2O (concd.), 620 (dil.) (269).

$C_{15}H_{16}N_3O(Cl)$.—3, 5-Trimethyldiaminophenazoxonium chloride: *633.1*, 579 in H_2O; *628.5*, 609.9, 575.3, in EtOH; *630.6*, 611.1, 577 in AmOH (155).

3-Aminopheno-6-dimethylamino-*o*-tolazoxonium chloride: *628.2*, 578.5 in H_2O; *625.7*, 603.9, 576 in EtOH; *628.2*, 606.7, 578.5 in AmOH (155); *cf.* (49q). Brilliant Cresyl Blue, 575 in H_2O (concd.), 625 (dil.); base, 485 in $CHCl_3$ (677).

$C_{16}H_{11}N_2O$.—3-Aminonaphthophenazoxonium salts: chloride, 581.7, *538.5*, 500.2 in H_2O (155); 586, 540, 499, 275, 315 in EtOH; triacid salt, 580 in 25% oleum; base, 519 in Et_2O (315).

6-Aminonaphthophenazoxonium salts: chloride, 464, 335, 285, 265 in EtOH (315); diacid salt, 575 in concd. H_2SO_4 (303); *cf.* (315).

$C_{16}H_{12}N_3O$.—3, 6-Diaminonaphthophenazoxonium salts: chloride, *590.4*, 544.5 in H_2O; *610.5*, 593, 545.5 in EtOH; *615.9*, 595.6, 570.7 in AmOH (155); monacid salt, ultra-violet bands at 320, 266 in EtOH; diacid salt, 460 in H_2SO_4; triacid salt, 585 in oleum (315).

3, 6-Tetramethyldiaminophenazoxonium salts: chloride, *648.9*, 591.4 in H_2O; *643.3*, 620.7, 588.6 in EtOH; *644.6*, 622.3, 589.8 in AmOH (155); nitrate, *645*, 588, 285, 260 in EtOH (313); *cf.* (221); triacid salt, 557, 518 (oleum) (309).

asym.-3, 6-Diethyldiaminophenazoxonium chloride; *622.5*, 573.2 in H_2O; *619.2*, 598.5, 569.3 in EtOH; *621.3*, 599.9, 571 in AmOH (155).

asym.-3, 6-Dimethyldiamino-2,7-di-*o*-tolazoxonium chloride: *631.4*, 581 in H_2O; *628.5*, 606.9, 578.5 in EtOH; *629.8*, 608.4, 580 in AmOH (155).

$C_{17}H_{20}N_3O(Cl)$.—3, 6-Tetramethyldiaminopheno-*o*-tolazoxonium chloride: *660*, 602.2 in H_2O; *653.7*, 597 in EtOH; *655.2*, 633.7, 597.9 in AmOH (155).

$C_{18}H_{14}N_3O(Cl)$.—3, 6-Phenyldiaminophenazoxonium chloride: *605*, 285, *265* in EtOH (312).

$C_{18}H_{15}N_2O$.—3-Dimethylaminonaphthophenazoxonium salts: chloride, 620.1, *572*, 531.2 in H_2O; 623, *574.5*, 533 in EtOH; *628.8*, *578.2*, 536.1 in AmOH (155); *cf.* (249, 303, 315); diacid salt, 520 (H_2SO_4) (315); influence of concn. (269). (Meldola's Blue, C. I. 909.)

3-Dimethylaminoisonaphthophenazoxonium salts: nitrate in EtOH with trace of HCl, 620, *582* (303).

$C_{18}H_{15}N_2O_2(Cl)$.—3-Dimethylamino-9-hydroxynaphthophenazoxonium chloride (C. I. 915): 627.8, *575.7*, 534.8 in H_2O; 637.6, *584.5*, 541.5 in EtOH; 647.2, *591.4*, 547.5 in AmOH (155).

$C_{18}H_{16}N_3O(Cl)$.—3-Dimethylamino-6-aminonaphthophenazoxonium chloride: *636.4*, 582.7 in H_2O; 624.5 in EtOH; 623.6 in AmOH (155); *cf.* (183, 303).

$C_{18}H_{22}N_3O(Cl)$.—*asym.*-3, 6-Dimethyldiethyldiaminophenazoxonium chloride: 651.7, 594.5 in H_2O; *645.1*, 622, 590.9 in EtOH; *646.9*, 623.9, 591.9 in AmOH (155).

3, 6-Triethyldiaminophenazoxonium chloride: *637.4*, 584.5 in H_2O; 632.4, (611.1), 579 in EtOH; *634.2*, 612.3, 581 in AmOH (155).

$C_{19}H_{18}N_3O(Cl)$.—3-Dimethylamino-6-aminonaphtho-*o*-tolazoxonium chloride (Cresyl Violet): 585 in H_2O; 603 in EtOH (6); *cf.* (162q).

$C_{19}H_{24}N_3O(Cl)$.—3-Dimethylaminopheno-6-diethylamino-*o*-tolazoxonium chloride (C. I. 876): *644.4*, 606.4 in H_2O; *656.7*, 599.9 in EtOH; *658.1*, 636, 601.3 in AmOH (155).

3-Diethylaminopheno-6-dimethylamino-*o*-tolazoxonium chloride: *653.7*, 632.7, 597.1 in EtOH; *656.3*, 634.7, 599.6 in AmOH; 603 in H_2O (155).

$C_{20}H_{18}N_3O(Cl)$.—3-Phenylamino-6-dimethylaminophenazoxonium chloride: 651, 265 in EtOH (313).

9-Acetylamino-3-dimethylaminoisonaphthophenazoxonium chloride: 590 in EtOH with trace of HCl (303).

$C_{20}H_{19}N_2O(Cl)$.—3-Diethylaminonaphthophenazoxonium chloride: 622.3, *573.3*, 532.1 in H_2O; 625.2, 575.7, 533.9 in EtOH; 631.1,

$C_{20}H_{19}N_2O(Cl)$.—(*Continued*)

579.5, 537 in AmOH (155); *cf.* (183); chlorate in EtOH with trace HCl, 629, *585*, 539 (303).

$C_{20}H_{19}N_2O(ClO_4)$.—3-Diethylaminoisonaphthophenazoxonium perchlorate: 625, 580 in EtOH with trace HCl (303).

$C_{20}H_{19}N_3O$.—3-Diethylamino-6-aminonaphthophenazoxine: 525 in abs. EtOH (303).

$C_{20}H_{20}N_3O(Cl)$.—3, 6-Tetramethyldiaminonaphthophenazoxonium chloride (C. I. 911): *662.2*, 603.5 in H_2O; 656.3 in EtOH; 652.6 in AmOH (155).

3-Dimethylamino-6-ethylaminonaphthophenazoxonium chloride: *641.8*, 587 in H_2O; 634.1 in EtOH; 633.7 in AmOH (155).

3-Diethylamino-6-aminonaphthophenazoxonium chloride: *643.5*, 592 in H_2O; 630.4 in EtOH; 629.4 in AmOH (155); polyacidic salts (303); influence of concn. (269). (The sulfate is Nile Blue A, C. I. 913. Nile Blue A-azodimethylaniline has max. abs. at 582 (111).)

$C_{20}H_{26}N_3O(Cl)$.—3, 6-Tetraethyldiaminophenazoxonium chloride: *654.6*, 597.4 in H_2O; 646.9, 624, 592.2 in EtOH; *649*, 626.1, 593.5 in AmOH (155).

$C_{21}H_{20}N_3O(Cl)$.—3-Phenylaminopheno-6-dimethylamino-*o*-tolazoxonium chloride: 656.3 in H_2O; 658.1 in EtOH or AmOH (155).

$C_{22}H_{21}N_3O_2$.—3-Diethylamino-6-acetylaminonaphthophenazoxine: 560 in abs. EtOH (303).

$C_{22}H_{22}N_3O_2(Cl)$.—3-Diethylamino-6-acetylaminonaphthophenazoxonium chloride: 662, *602* in EtOH with trace HCl (303).

3-Diethylamino-9-acetylaminoisonaphthophenazoxonium chloride: 596 in EtOH with trace HCl (303).

$C_{24}H_{18}N_3O(Cl)$.—*sym.*-3, 6-Diphenyldiaminophenazoxonium chloride: 664, 285, 265 in EtOH (313).

$C_{24}H_{20}N_3O(Cl)$.—3-Dimethylamino-9-phenylaminonaphthophenazoxonium chloride: 605.5, *555.9*, 518.6 in H_2O; 585.7, 545.5 in EtOH; 585, 543.5 in AmOH (155).

3-Dimethylamino-6-phenylaminonaphthophenazoxonium chloride: 645 in EtOH with trace HCl (303).

$C_{24}H_{28}N_3O(Cl)$.—3, 6-Tetraethyldiaminonaphthophenazoxonium chloride: *671.4*, 615.3 in H_2O; 671.4 in EtOH; 674.6 in AmOH (155).

$C_{25}H_{22}N_3O(Cl)$.—3-Dimethylamino-6-*p*-tolylaminonaphthophenazoxonium chloride: 670, 600 in H_2O; 670 in EtOH (183).

$C_{26}H_{22}N_4O_2(Cl)_2$.—Di-Meldola's Blue: 702 (111).

$C_{26}H_{24}N_3O(Cl)$.—3-Diethylamino-6-phenylaminonaphthophenazoxonium chloride: triacid salt, 582 (303).

$C_{27}H_{26}N_3O(Cl)$.—3-Diethylamino-6-*p*-tolylaminonaphthophenazoxonium chloride: *670*, 615 in H_2O; 670 in EtOH (183).

3-Diethylamino-6-benzylaminonaphthophenazoxonium chloride (C. I. 914): 592 in H_2O (concd.), 650 (dil.) (269).

$C_{32}H_{28}N_3O$.—3-Diethylamino-6-diphenylaminonaphthophenazoxine: 550 in abs. EtOH (303).

Table 9.—Thiazine Derivatives

$C_{12}H_5Cl_4NS$.—Tetrachlorothiodiphenylamine: 596 in H_2SO_4 (625).

$C_{12}H_6N_4O_6S$.—1, 3, 6-Trinitrothiodiphenylamine: 667 in alk. EtOH (304).

$C_{12}H_7Cl_2NS$.—Dichlorothiodiphenylamine: 569 in H_2SO_4 (625).

$C_{12}H_7NOS$.—3-Oxythiazine (Thiazone): 543 in H_2O; (acid salts) (529).

$C_{12}H_7NO_2S$.—6-Hydroxythiazone (Thionol): *584.5*, 544.5 in H_2O; *594.8*, 558 with alkali; 607.2, *596*, 579, 554.8 with alk. EtOH (155); *cf.* (465).

$C_{12}H_7N_3O_4S$.—1, 3-Dinitrothiodiphenylamine: (595), 520 in alk. EtOH (304).

3, 6-Dinitrothiodiphenylamine: 492 in alk. EtOH (304).

$C_{12}H_8ClNS$.—Chlorothiodiphenylamine: 544 in H_2SO_4 (625).

$C_{12}H_8N_2O_2S$.—3-Nitrothiodiphenylamine: 703, 641, 589 in alk. EtOH (304).

$C_{12}H_8N_2OS$.—3-Hydroxy-6-aminothiazine (Thionoline): *592.2*, 547.5 in H_2O; *595.3*, 580, 552.6 in EtOH (155); *cf.* (5, 42).

$C_{12}H_8NS$.—Thiazine: acid salt, 518, 435; diacid salt, 520, 460, 290 (H_2SO_4) (313); *cf.* (309, 323).

$C_{12}H_9NS$.—Thiodiphenylamine: 520, 478, 461 in H_2SO_4 (*Ber.* **27**: 3321; 94).

$C_{12}H_9N_2S$.—1-Aminothiazine: acid salt, 410, 290 in acid EtOH; diacid salt, 540, 440, 290 (H_2SO_4) (313); *cf.* (309).

3-Aminothiazine (Thiazime): chloride, 598.5, *554.8*, 516 in H_2O; 593, *548.5*, 511.2 in EtOH (155); 292 (H_2O) (311); diacid salt, 470 (H_2SO_4) (309); *cf.* (42, 323, 529).

$C_{12}H_{10}N_2S$.—Aminothiodiphenylamine: *555.9*, 515.2 in H_2O (153).

$C_{12}H_{10}N_3S(Cl)$.—1, 3-Diaminodiphenazthionium chloride: 486, 310 in dil. H_2SO_4 (309).

2, 7-Diaminodiphenazthionium chloride: 535 (42); 532 (625).

3, 6-Diaminodiphenazthionium chloride (Thionine, C. I. 920); *602.5*, 559.4 in H_2O; *605.3*, 588.3 in EtOH (155); 284 in H_2O (309); triacid salt, 470 (H_2SO_4) (309); influence of temp. (57); influence of concn. (269); *cf.* (5, 42, 111, 307, 465, 529q).

$C_{13}H_{11}N_2S(ClO_4)$.—3-Methylaminodiphenazthionium perchlorate: *596*, 553, (514), 290 in acid EtOH (311).

$C_{13}H_{11}NOS$.—*N*-Methylthiodiphenylamine sulfoxide: acid salt, 515; diacid salt, 460 (H_2SO_4) (313).

$C_{13}H_{12}N_3S(Cl)$.—Methylthionine chloride: *611.4*, 568.2 in H_2O; *614.7*, 598.5, 567 in EtOH (155).

3, 6-Diaminopheno-*o*-tolazthionium chloride: *604.4*, 562.5 in H_2O; *607.2*, 590.9 in EtOH (155).

3, 6-Diaminopheno-*m*-tolazthionium chloride: 592 in H_2O (153); *604.4*, 587.5 in EtOH (155).

$C_{14}H_8Br_4N_2OS$.—Tetrabromomethylene violet: 580, 536 in $C_6H_5CH_3$; 590, 557 in $C_6H_5NO_2$; 612 in H_2SO_4; *551*, 596 in HOAc; 600, 557 in AmOH (625, 580 with KOEt) (182).

$C_{14}H_{11}N_2OS(Cl)$.—3-Acetaminodiphenazthionium chloride: 556, *458* in H_2O (529).

$C_{14}H_{12}NS$.—3, 6-Dimethylthiazine: holo- and meriquinoid salts; visible and ultra-violet spectrum of sulfate (323); visible spectrum of chloride (529).

$C_{14}H_{13}N_2S(ClO_4)$.—3-Dimethylaminodiphenazthionium perchlorate: 635, *586*, (536), 293 in EtOH (311).

$C_{14}H_{13}N_2OS(Cl)$.—Dimethylthionoline chloride (Bernthsen's Methylene Violet): *622.3*, 573.2 in H_2O; *601.6*, 558.1 in EtOH (155); *cf.* (5, 42).

$C_{14}H_{14}N_3S(Cl)$.—*sym.*-Dimethylthionine chloride: *620.1*, 574.5 in H_2O; *617.8*, 572 in EtOH (155); *cf.* (5).

asym.-Dimethylthionine chloride (Azure A): *638*, 587 in H_2O; 630.1, 579.5 in EtOH (155); *cf.* (307); influence of temp. (57).

Ethylthionine chloride: *612.2*, 570.7 in H_2O; *617.1*, 600.7, 569.5 in EtOH (155).

$C_{15}H_{16}N_3S(Cl)$.—*asym.*-Dimethyldiaminopheno-*o*-tolazthionium chloride: *640*, 588.3 in H_2O; *630.8*, 580.2 in EtOH (155). Toluidine Blue O (C. I. 925): 580 in H_2O (concd.), 635 in H_2O (dil.) (269).

asym.-Dimethyldiaminopheno-*m*-tolazthionium chloride: *627.6*, 578.2 in H_2O; 626.5, 630, 579.5 in EtOH (155).

Trimethylthionine chloride: *651.7*, 596.1 in H_2O; 642.4, 588.3 in EtOH (155); *cf.* (277).

$C_{16}H_{14}N_3O_2S(Cl)$.—Diacetylthionine chloride: 535 in H_2O (529).

$C_{16}H_{17}INS(I)$.—Iodomethylene blue iodide: *661.4*, 610.9 in H_2O; *659.2*, 610.2 in EtOH (180).

$C_{16}H_{17}N_2S(Br)$.—3-Diethylaminodiphenazthionium bromide: 638, *589*, (540), 293 in acid EtOH (311).

$C_{16}H_{17}N_2OS(Cl)$.—Diethylthionoline chloride: *625.5*, 577 in H_2O; *607.2*, 561.8 in EtOH (155).

$C_{16}H_{17}N_4O_2S(Cl)$.—Nitromethylene blue: 658, 606, (470), 280 in H_2O; 400, 300 in 90% H_2SO_4 (309). Methylene Green B (C. I. 924): 665 on cotton (627); influence of concn. (269).

$C_{16}H_{18}N_3S(Cl)$.—*sym.*-Diethylthionine chloride: *621.6*, 575.7 in H_2O; *619.2*, 573.2 in EtOH (155); *cf.* (5).

asym.-Diethylthionine chloride: *641*, 590.9 in H_2O; *633.7*, 582 in EtOH (155); *cf.* (181).

Tetramethylthionine chloride (Methylene Blue, C. I. 922): *667.5*, 608.4 in H_2O; *657.4*, 602.1 in EtOH (155); ultra-violet bands, 290, 243 in EtOH (302); influence of temp. (57, 426); influence of acidity (276, 309); influence of concn. and solvent (269, 276); lakes (265); dyeings (522); solid dye (269); dye base, 527 in $CHCl_3$ (677); *cf.* (5, 161q, 277q, 299q, 307, 581).

$C_{16}H_{19}N_4S(I)$.—Aminomethylene blue iodide: 647.5, 578 in AmOH (180); *cf.* (309).

$C_{17}H_{20}N_3S(Cl)$.—Trimethylethylthionine chloride (C. I. 926): *668.5*, 609.9 in H_2O; *658.1*, 603 in EtOH (155).

Diethylmethylthionine chloride: *655*, 600.2 in H_2O; *645.1*, 590.9 in EtOH (155).

Diethylaminophenoamino-*o*-tolazthionium chloride: *643.2*, 593.5 in H_2O; *634.7*, 583.2 in EtOH (155).

Diethylaminophenoamino-*m*-tolazthionium chloride: *630*, 582 in H_2O; 630.1, 607.5, 582 in EtOH (155).

$C_{18}H_{13}N_2S(Cl)$.—3-Phenylaminodiphenazthionium chloride: 592, (428) in H_2O (529); *626*, 572, 290 in acid EtOH (311).

$C_{18}H_{14}N_3S(NO_3)$.—Phenylthionine nitrate: 625, 290 in acid EtOH (302).

$C_{18}H_{22}N_3S(Cl)$.—Triethylthionine chloride: *655.9*, 601.6 in H_2O; *646.5*, 592.2 in EtOH (155).

sym.-Diethyldimethylthionine chloride: 672.2 in H_2O; 659.9 in EtOH; 658.9 in $CHCl_3$; 668.5 in CS_2; influence of temp. (57).

asym.-Diethyldimethylthionine chloride: *670*, 611.4 in H_2O; *659.2*, 604.1 in EtOH (155); influence of temp. (57); *cf.* (5).

Diethyldiaminodi-*o*-tolazthionium chloride (C. I. 927): New Methylene Blue, 575 in H_2O (concd.), 630 (dil.) (269); on cotton, 610 (627).

$C_{19}H_{15}N_2S(Br)$.—3-Phenylmethylaminodiphenazthionium bromide: 637, *607*, (539), 296 in acid EtOH (311).

$C_{19}H_{16}N_3S(Cl)$.—*asym.*-Phenylmethylthionine chloride: 627, 288 in acid EtOH (302).

$C_{19}H_{24}N_3S(Cl)$.—Methyltriethylthionine chloride: *671.5*, 612.9 in H_2O; *660.2*, 604.7 in EtOH (155).

Diethylaminophenoethylamino-*o*-tolazthionium chloride: 658.9, 605.8 in H_2O; *647.2*, 592.7 in EtOH (155).

$C_{20}H_{25}BrN_3S(Br)$.—Bromotetraethylthionine bromide: *670*, 624 in H_2O; *676*, 614.8 with KOH (181).

$C_{20}H_{25}N_4O_2S(Br)$.—Nitrotetraethylthionine bromide: 639.7 in H_2O; 672 in EtOH (181).

$C_{20}H_{26}N_3S(Cl)$.—Tetraethylthionine chloride: *673*, 614.3 in H_2O; *661.1*, 605.5 in EtOH (155); 664.7 in $CHCl_3$; 667.4 in CS_2; influence of temp. (57).

$C_{20}H_{27}N_4S(Br)$.—Aminotetraethylthionine bromide: *623.8* in EtOH (181).

$C_{21}H_{20}N_3S(NO_3)$.—Phenyltrimethylthionine nitrate: 645, 290 in EtOH (302).

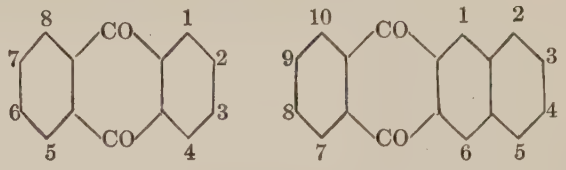
$C_{24}H_{18}N_3S(Cl)$.—*sym.*-Diphenylthionine chloride: 700, 290 in acid EtOH (302).

$C_{26}H_{22}N_3S(Cl)$.—*sym.*-Diphenyldimethylthionine chloride: 670, 290 (302).

$C_{28}H_{26}N_7S(OH)$.—Thioninedisazo-*bis*-dimethylaniline: 505 (111).

"Methylene Azure:" (42, 57, 581).

TABLE 10.—ANTHRAQUINONE DERIVATIVES



Abbreviations: S. B. A. = sulfuric-boric acid; B. A. A. = boric acid-acetic anhydride

$C_{14}H_5Br_3O_5$.—Tribromoflavopurpurin: 537.4, 498.4 in dil. H_2SO_4 (350).

$C_{14}H_5Br_3O_6$.—Tribromohydroxyanthrapurpurin: *570*, 532 in alk. H_2O; 548, *506*, 474 in H_2SO_4; *557*, 516 in S. B. A. (101).

$C_{14}H_6Br_2O_4$.—Dibromoquinizarin: 605, 570 in dil. KOH; 555, 518 in H_2SO_4 (107); 578, 534 in B. A. A. (103).

$C_{14}H_7BrO_4$.—3-Bromoalizarin: 515, 481.5 in H_2SO_4 (350).

2-Bromoquinizarin: 603, 565 in dil. KOH; 553, 515 in H_2SO_4 (107); 570, 530 in B. A. A. (103).

$C_{14}H_7BrO_5$.—Bromopurpurin: 524.7, 492.4 in H_2SO_4 (350).

$C_{14}H_7ClO_4$.—2-Chloroquinizarin: 565, 528 in B. A. A. (103); 601 in alk. H_2O (467).

$C_{14}H_7FO_4$.—2-Fluoroquinizarin: 560, 522 in B. A. A. (103).

$C_{14}H_7NO_6$.—3-Nitroalizarin (C. I. 1033): 518.3, 490.4 in H_2SO_4 (350); 577.7, *533.7*, 494 in alk. H_2O (155).

4-Nitroalizarin (C. I. 1031): 601.9, *557*, 519.5 in alk. H_2O; 564.7, 525.8 in EtOH (609.6, *564.7*, 526.7 with alkali) (155).

$C_{14}H_7NO_7$.—Nitroflavopurpurin: 525.1, 493.4 in dil. H_2SO_4 (350).

$C_{14}H_8O_2$.—Anthraquinone: 412, 310, 265 in H_2SO_4 (443).

$C_{14}H_8O_3$.—1-Hydroxyanthraquinone: 570.4, 522.9, 495 in $CHCl_3$; 570, 515.9, 495 in Et_2O; 551.6 in H_2SO_4 (350); 475, 305, 262 in H_2SO_4 (443); 500, *480* with excess alkali (474); *cf.* (431, 457).

2-Hydroxyanthraquinone: 500, 410, 320, 288 in H_2SO_4; alkali salt, 492, 300, 238 in H_2O (443); 495, *470* with excess alkali (474); *cf.* (457).

$C_{14}H_8O_4$.—1, 2, Dihydroxyanthraquinone (Alizarin, C. I. 1027): in H_2SO_4, 605.4, 493.1 (351); (540.5), *497*, 464 (155); 625, 501, 316, 270 (443); *cf.* (350, 379, 430); in S. B. A. (617.5), (569.5), *500*, 466.3 (155); in EtOH, 455, (286), 247 (394); with excess alkali in H_2O, 610.8, *566.5*, 527.6; in EtOH, 624.9, *578.2*, 537.1 (155); *cf.* (443, 474); alkali salt, 527, 330, 260; on mordants, Sn, 473, Al, 507, Cr, 528 (431); absorption in solid and vapor form (336).

1, 4-Dihydroxyanthraquinone (Quinizarin, C. I. 1028): in EtOH, 516, 502.1, *484.4*, 468.8, 453.9 (155); *cf.* (430, 431); 314, 279, 244 (394); in H_2SO_4, *548.3*, 509.6, 476.4 (155); *cf.* (351, 379, 430); 325, 272 (443); in S. B. A., *547.5*, 508.8, 475.5 (155); in B. A. A., 558, 520 (103); *cf.* (105); in vapor form, 513.7, 504, 492.6, 481.5, 473.6, 463.5 (430); with excess alkali in EtOH, *608.1*, 565.4, 529.4; in H_2O, *596.1*, 553.7, 517.7 (155); *cf.* (430, 431, 443, 474); on mordants, Sn, (546), 492, Al, 575, 528, Cr, 587, (537) (431).

1, 5-Dihydroxyanthraquinone (Anthrarufin, C. I. 1029): in H_2SO_4, *570.7*, 557.7, *528.5*, 517.7, 487.1 (155); *cf.* (350); 320, 272 (443); in S. B. A., *570.7*, 550, *528.2*, 515.2, 491.3, (459.5) (155); in B. A. A., 570, 527 (105); with excess alkali, 500, *470* (474); *cf.* (443).

1, 7-Dihydroxyanthraquinone: 501.4 in H_2SO_4 (350).

1, 8-Dihydroxyanthraquinone (Chrysazin, C. I. 1030): 533, *495.6*, 465.9 in H_2SO_4; 533.9, *496.5*, 466.9 in S. B. A. (155); 597.9, 538 (350).

2, 3-Dihydroxyanthraquinone (Hystazarin): 619.8, 587.4 in dil. NaOH (351).

2, 6-Dihydroxyanthraquinone (Anthraflavin): 495, 462.6 in H_2SO_4 (351); *cf.* (350, 379); 293 (443); alkali salt, 500, 406, 338, 290 in H_2O (443); with excess alkali, 485, *430*, 400 (474).

$C_{14}H_8O_4$.—2, 7-Dihydroxyanthraquinone (Isoanthraflavin): 539.7, 493.6 in H_2SO_4 (350); *cf.* (379); 303 (443); alkali salt, 505, 394, 343, 305 in H_2O (443); with excess alkali, 500, *475*, 390 (474).

$C_{14}H_8O_5$.—1, 2, 3-Trihydroxyanthraquinone (Anthragallol, C. I. 1035): in H_2SO_4, 575, *525.6*, 486.4, 456.6 (155); *cf.* (156, 350, 379, 430); also 291 (443); in S. B. A., *522.5*, 486.5, 455 (band at 578 due to by-product) (156); alkali salt (620), 509, 428, 288 (443).

1, 2, 4-Trihydroxyanthraquinone (Purpurin, C. I. 1037): in H_2SO_4, 559.9, 520.4, 489.2 (155); *cf.* (350, 430); (320), 280 (443); in S. B. A., 559.9, 520.4, 489.2 (155); in EtOH, 521.1, *485.5*, 455.5 (155); *cf.* (430, 431); in vapor form, 525.6, 504.5 (430); alkali salt, *546.7*, 508.9, 477.7 (155); *cf.* (430, 431); 275 (443); in alk. EtOH, *550.7*, 512.8, 481.5 (155); on mordants: Sn, 538, 512, Al, 553, 520, Cr, 564, 530 (431).

1, 2, 5-Trihydroxyanthraquinone (Brilliant Alizarin Bordeaux R, C. I. 1038): in H_2SO_4, 640, 573.2, 530, 501 (430); *cf.* (155, 350); in S. B. A., 640.4, *587*, 512.8 (155); in EtOH, (523.8), 470; in vapor form, *513.5*, *505*, 489.6, 480.5, 469.3 (430); with excess alkali, 619.5, *573.2*, 533.5 in H_2O; 631.5, *583*, 541.1 in EtOH (155); *cf.* (430).

1, 2, 6-Trihydroxyanthraquinone (Flavopurpurin, C. I. 1039): in H_2SO_4, 531.2, *490.2*, 457.8 (155); *cf.* (351); in dil. H_2SO_4, 533.5, 495.4 (350); *cf.* (379); in S. B. A., 534.8, *492.3*, (456.6) (155); in excess alkali, 594.8, *551*, 512.8 in H_2O (155); *cf.* (351); 601, 557, 518.5 in EtOH (351).

1, 2, 7-Trihydroxyanthraquinone (Anthrapurpurin, C. I. 1040): in H_2SO_4, 548.5, *508.8*, 478.3 (155); *cf.* (350); in S. B. A., 687, *512.6*, 479.3, 448.9; with excess alkali, 605.8, *561.8*, 523 in H_2O; 610.8, *567*, 527.6 in EtOH (155).

1, 2, 8-Trihydroxyanthraquinone: in H_2SO_4, *549.5*, 510, 478.3; in S. B. A., *594.3*, 548.9, 514.4; in alk. H_2O, 618, 570.7, *534*, 498.5; in alk. EtOH, *631.1*, 583, 540.5, 505.5 (155).

1, 4, 5-Trihydroxyanthraquinone: *584.2*, 539.1, 497.7 in H_2SO_4; *595.6*, 550.5, 511.3 in S. B. A.; 526.7, 512.8, *492.5*, 478.9, 462 in EtOH (611.7, *560.7*, 521.3 with alkali); 598.8, *553.7*, 516.3 in alk. H_2O (155).

1, 4, 6-Trihydroxyanthraquinone: 587, 554, *515* in H_2SO_4; 561, 513 in S. B. A.; *591*, 553 in alk. H_2O (101).

$C_{14}H_8O_5S$.—1-Sulfoanthraquinone: *385*, 340 in alk. H_2O (474).

$C_{14}H_8O_6$.—1, 2, 5, 8-Tetrahydroxyanthraquinone (Quinalizarin, C. I. 1045): 637.7, *573.2*, 530.3, 492 in H_2SO_4; 635.4, *590.9* in S. B. A.; 530.7, 517.0, *490.2*, 461.4 in EtOH; (649.7, 634.1), 590.1, 546.5 with alkali; *587.0*, 543.5, (506.4) in alk. H_2O (155); *cf.* (350, 431); on mordants: Sn, 510; Al, 542; Cr, 548 (431).

Oxyflavopurpurin; *523*, 490 in H_2SO_4; *534*, 494 in S. B. A.; *541*, 501 in alk. H_2O (101).

Oxyanthrapurpurin; 587, 534, *500*, 467 in H_2SO_4; 590, *489*, 469 in S. B. A.; *561*, *521*, 489 in alk. H_2O (101).

1, 3, 5, 7-Tetrahydroxyanthraquinone (Anthrachrysone): 508.3, 471.7 in H_2SO_4 (350).

1, 4, 5, 8-Tetrahydroxyanthraquinone: *636.4*, 617.1, *584.2*, 539.9, 526.2 in H_2SO_4; *637.7*, 618.3, *585.5*, 568.7, 541.1, 527.4 in S. B. A.; *558*, 543.9, *519.7*, 507.1, 485.6, 475.1 in EtOH; 620.7, 574, 533.9 in alk. H_2O (155).

2, 4, 6, 8-Tetrahydroxyanthraquinone: *504.8*, 472 in H_2O; *512.8*, 478.3 in S. B. A.; 449.5 in EtOH; (541) in alk. H_2O (155).

$C_{14}H_8O_7$.—1, 2, 4, 5, 8-Pentahydroxyanthraquinone (Alizarin Cyanin, C. I. 1050): *633.2*, 583, 538.5 in H_2SO_4; *629.8*, 577, 532.5 in S. B. A.; *559.2*, 545.3, 520.2, 507.7, 485.9, 475.5 in EtOH (*587*, 543.9, 507.4 with alkali); *581.7*, 538.7, 520.4 in alk. H_2O (155); on mordants: Sn, 555; Al, 584; Cr, 592 (431); in organic solvents (430).

$C_{14}H_8O_8$.—1, 2, 3, 5, 6, 7-Hexahydroxyanthraquinone (Rufigallol, C. I. 1052): 576.5, 531.9 in H_2SO_4 (351); *cf.* (350, 379); *572.5*, 530.3, 457, (432) in H_2SO_4; 576.2, 534 in S. B. A. (155); 443 in EtOH (431); on mordants: Sn, 478; Al, 496; Cr, 510 (431).

1, 2, 4, 5, 6, 8-Hexahydroxyanthraquinone (C. I. 1062): *603*, 588.3, *555.9*, 542.5, 513.6 in H_2SO_4; *599.7*, 550.7, 506.4 in S. B. A.; *546.3*, 533.5, 521.3, 508.7, 496.9, 486.7, 475.9, 465.5 in EtOH (155).

1, 2, 4, 5, 7, 8-Hexahydroxyanthraquinone (C. I. 1064): (661.5), *584.3*, 540.5, 502.4 in H_2SO_4; *649.5*, 593.5, 546.5, 506.4 in S. B. A.; (611), *568.2*, 550.5, *527.8*, 512, 492.3, 480 in EtOH (155).

1, 3, 4, 5, 7, 8-Hexahydroxyanthraquinone: (675), 604.4, 556.4, 519 in H_2SO_4; 565.5, *548.7*, *534.8*, 508.9, 499.5, (487.5) in EtOH (430); *cf.* (431); on mordants: Sn, 550; Al, 592; Cr, 600 (431).

$C_{14}H_8O_8S_2$.—1, 5-Disulfoanthraquinone: *420*, 333 in alk. H_2O (474).

$C_{14}H_9NO_3$.—1-Hydroxy-4-aminoanthraquinone: *562.5*, 522.2 in H_2SO_4; *571.2*, 528.3, 486, 455 in S. B. A.; 570.2, *529.4*, 493 in EtOH (*602.7*, 559.4, 521.7 with alkali); *590.7*, 548.5, 511.2 in alk. H_2O (155).

$C_{14}H_9NO_4$.—1, 2-Dihydroxy-4-aminoanthraquinone (C. I. 1032): 560.3, 515.2, 485 in H_2SO_4; 569.5, *526.7*, 489 in S. B. A.; 564, *523.5*, 488.5 in EtOH (*567.7*, 527.6, 491.7 with alkali); *559.2*, 519.9, 486.4 in alk. H_2O (155); (531.3, 495.2 in H_2SO_4 (350)).

394, 343, 305 1, 2-Dihydroxy-3-aminoanthraquinone: 540.3, 499.4 in H_2SO_4 (350).

2, 4-Dihydroxy-1-aminoanthraquinone: *550.9*, 510.5, 480.5, 450 in H_2SO_4; *552.6*, 511.7, 477, 448 in S. B. A.; 552.8, *515.2*, 482.5 in EtOH (555.5, *520.6*, 487.8 with alkali); 545.9, *510.4*, 480.7 in alk. H_2O (155).

$C_{14}H_{10}N_2O_2$.—1, 4-Diaminoanthraquinone (*584.5*, 568.2), (537.3, 526.7), (497, 492.4) in S. B. A.; 595.6, 551.3, 512.7 in EtOH (155).

$C_{14}H_{10}N_2O_4$.—1, 5-Dihydroxy-4, 8-diaminoanthraquinone: *617.7*, 568, 523 in H_2SO_4; (626.1, 609.9), (577.7, 562.9), (536, 524), in EtOH (*641.4*, 591, 547.5 with alkali) (155).

$C_{14}H_{12}N_4O_2$.—1, 4, 5, 8-Tetraaminoanthraquinone: 576, *531.5*, 507.5 in S. B. A.; *638.7*, 590.4, 549.3 in EtOH (*625.5*, 578.2, 536.6 with acid) (155).

$C_{15}H_7Br_3O_6$.—Tribromococcin: *556*, *514*, 482 in H_2SO_4; *570*, 528 in S. B. A.; 581, 538 in alk. H_2O (101).

$C_{15}H_8O_7$.—Purpurincarboxylic acid (pseudopurpurin): 563.5, 520.8, 489.8 in H_2SO_4 (350).

$C_{15}H_9BrO_5$.—2-Methoxy-3-bromoquinizarin: 520, 485 in H_2SO_4; 540, 505 in S. B. A.; 540, 505 in dil. KOH (107).

$C_{15}H_{10}O_3$.—1-Hydroxy-4-methylanthraquinone: 555.2 in H_2SO_4; 523.5 in $CHCl_3$ (350).

$C_{15}H_{10}O_4$.—1, 8-Dihydroxy-3-methylanthraquinone: 604.8, 534.4, 499.2 in H_2SO_4 (350).

$C_{15}H_{10}O_5$.—Methylhydroxyalizarin: 607.2, 569.4, (519.7) in H_2SO_4 (350).

α-Methylanthragallol: 541.5, 502.4 in H_2SO_4 (350).

1, 4, 6-Trihydroxy-8-methylanthraquinone: 580, 524, 486 in H_2SO_4; *579*, 527, 486 in S. B. A.; *595*, 532 in alk. H_2O (101).

1, 5, 8-Trihydroxy-2-methylanthraquinone: 459 in EtOH + HCl; 517 in EtOH + NaOH (195).

1, 5, 8-Trihydroxy-3-methylanthraquinone: 487 in EtOH + HCl; 557 in EtOH + NaOH (195).

1, 5, 8-Trihydroxy-4-methylanthraquinone: 478 in EtOH + HCl; 520 in EtOH + NaOH (195).

2, 5, 8-Trihydroxy-1-methylanthraquinone: 468 in EtOH + HCl; 532 in EtOH + NaOH (195).

$C_{15}H_{10}O_6$.—Methyltetrahydroxyanthraquinone: *540*, 501 in H_2SO_4; *546*, 503 in S. B. A.; *539*, 501 in alk. H_2O (101).

$C_{16}H_{12}O_4$.—Dimethylanthrarufin: 569.4, 520.8 in H_2SO_4 (350).

Alizarin dimethyl ether: 597.6, 487.5 in H_2SO_4 (351); *cf.* (379).

Quinizarin dimethyl ether: 564.4, 519.8, (484.3) in H_2SO_4; 577.4, 535.4, 494.1 in neutral soln. (351); *cf.* (379).

Anthraflavin dimethyl ether: 501.5, 472.6, (436.9) in H_2SO_4 (351); *cf.* (379).

$C_{16}H_{12}O_5$.—Dimethylanthragallol: 544.3, 507.5 in H_2SO_4 (350).

Anthragallol ethyl ether: 515 in H_2SO_4 (351); *cf.* (379).

$C_{16}H_{12}O_6$.—Dimethyltetrahydroxyanthraquinone (probably 1, 5-dimethylanthrachrysone): 635.3, 617.8, 582.4, 540.3 in H_2SO_4 (350).

$C_{16}H_{14}N_2O_2$.—1, 4-Dimethylaminoanthraquinone: (624.9, 602.5), (572.0, 552.8), (526.7, 509.6) in S. B. A.; *644.5*, 595.1, 550.5 in EtOH (155).

$C_{17}H_9NO_4$.—1, 2-Dihydroxyanthraquinone-α-quinoline (C. I. 1068): 597.7, 551.5, *516.8*, 487.8 in H_2SO_4; 660, *603* in S. B. A.; 588.8, *545.5*, 507.2 in EtOH; 578.3, *535.3*, 497.3 in H_2O; *567.5*, 526.9, 491.9 in alk. H_2O; *576*, 530.5, 494.7 in alk. EtOH (155).

1, 2-Dihydroxyanthraquinone-β-quinoline (C. I. 1066): 604.4, *560.7*, 524, 492.7 in H_2SO_4; 578 in S. B. A.; *675*, 617.7, (579.5) in alk. H_2O; *690.6*, 632.1, 580.7 in alk. EtOH (155). Alizarin Blue: on wool (10); infra-red bands at 0.8 and 1.0μ with strong band at 0.5μ in EtOH (388).

$C_{17}H_{14}O_5$.—Trimethylanthragallol: 554.1, 507.5 in H_2SO_4 (350).

1-Hydroxy-2-methyl-5, 8-dimethoxyanthraquinone: 460 in EtOH + HCl; 507 in EtOH + NaOH (195).

1-Hydroxy-3-methyl-5, 8-dimethoxyanthraquinone: 473 in EtOH + HCl; 525 in EtOH + NaOH (195).

1-Hydroxy-4-methyl-5, 8-dimethoxyanthraquinone: 467 in EtOH + HCl; 506 in EtOH + NaOH (195).

$C_{18}H_{16}O_4$.—Quinizarin diethyl ether: 577, 535, (494) in H_2SO_4 (379).

Anthraflavin diethyl ether: 504.5, 477.5, (439.8) in H_2SO_4 (351); *cf.* (379).

Isoanthraflavin diethyl ether: 505.1, 492.3 in H_2SO_4 (351); *cf.* (379).

$C_{18}H_{16}O_5$.—Anthragallol diethyl ether: 515 in H_2SO_4 (379).

Anthrapurpurin diethyl ether: 508.1 in H_2SO_4 (351).

Flavopurpurin diethyl ether: 542.3, 501.5 in H_2SO_4 (351); *cf.* (379).

$C_{18}H_8N_2O_7$.—1-Hydroxy-2, 6-dinitronaphthacenequinone: 416 in EtOH (521, 408 with NaOEt) (41).

$C_{18}H_9ClO_3$.—1-Chloro-6-hydroxynaphthacenequinone: 571, 523, 304 in S. B. A.; 458, 250 in EtOH (510, 402, 261 with NaOEt) (41).

$C_{18}H_{10}O_3$.—1-Hydroxynaphthacenequinone: 571, 324 in S. B. A.; 455, 249 in EtOH (526, 263 with NaOEt) (41).

$C_{18}H_{10}O_4$.—1, 6-Dihydroxynaphthacenequinone: *540*, 492, 463, 331, *294* in S. B. A.; 488, 260 in EtOH (555, 265 with NaOEt) (41).

1, 7-Dihydroxynaphthacenequinone: 613, 571, 297 in S. B. A.; 476 in EtOH (488, 250 with NaOEt) (41).

1, 8-Dihydroxynaphthacenequinone: 571, 323 in S. B. A.; 454, 291 in EtOH (508, 472, 250 with NaOEt) (41).

$C_{18}H_{10}O_5$.—1, 2, 6-Trihydroxynaphthacenequinone: 570, 326 in S. B. A.; 488, 280 in EtOH (513 with NaOEt) (41).

$C_{18}H_{10}O_7S$.—1, 5-Dihydroxynaphthacenequinone-4 (?)-sulfonic acid: 610, 571, 300 in S. B. A.; 488, 260 in EtOH (588 with NaOEt) (41).

$C_{18}H_{11}NO_3$.—1-Amino-6-hydroxynaphthacenequinone: 541, 508, 292 in S. B. A.; 556, 510, 481, 264 in EtOH (562, 264 with NaOEt) (41).

$C_{18}H_{11}NO_4$.—1-Amino-6, 8-dihydroxynaphthacenequinone: 571, 293 in S. B. A.; 556, 513, 477 in EtOH (588, 250 with NaOEt) (41).

$C_{19}H_{12}O_4$.—1-Hydroxy-5-methoxynaphthacenequinone: 700, 300 in S. B. A.; 481, 252 in EtOH (530, 261 with NaOEt) (41).

1-Hydroxy-8-methoxynaphthacenequinone: 571, 327 in S. B. A.; 467, 290 in EtOH (532, 260 with NaOEt) (41).

$C_{20}H_{13}NO_3$.—1-Hydroxy-4-phenylaminoanthraquinone: *585*, 540.5 in H_2SO_4; *592.7*, 546.5, 506.4 in S. B. A.; 588.6, *546.5*, 508.3 in EtOH; *631.5*, 583.2, 541.1 in alk. EtOH (155).

$C_{20}H_{20}O_5$.—Flavopurpurin triethyl ether: 535.3, (489.5), 468.4 in H_2SO_4 (351).

$C_{20}H_{20}O_8$.—Rufigallol triethyl ether: 579, 544.6 in H_2SO_4 (351); *cf.* (379).

$C_{21}H_{13}NO_4$.—1-Benzoylamino-4-hydroxyanthraquinone (Algol Pink R, C. I. 1128): *577*, 534.5, 489.5 in H_2SO_4 (190); *cf.* (116); 538, 496 in C_9H_7N (116).

$C_{21}H_{13}NO_6$.—1-Benzoylamino-4, 5, 8-trihydroxyanthraquinone (Algol Violet B, C. I. 1130): 656, 603, 529, 495 in H_2SO_4; 637, 559, 523 in C_9H_7N (116); 600, 575 on cotton (522).

$C_{21}H_{14}N_2O_3$.—α-Benzoylhydrazinoanthraquinone: 540, 500, 300, 264 in H_2SO_4 (560, 530 on adding H_3BO_3) (39).

β-Benzoylhydrazinoanthraquinone: 504, 400, 303, 254 in H_2SO_4 (39).

$C_{21}H_{15}NO_3$.—1-Hydroxy-4-*o*-tolylaminoanthraquinone: *586.5*, 541.5 in H_2SO_4; *591.5*, 545.3, 505 in S. B. A.; 583.5, *542*, 504 in EtOH (*628.2*, 579.5, 538 with alkali) (155).

1-Hydroxy-4-*p*-tolylaminoanthraquinone: *587*, 542.5 in H_2SO_4; 592.2, 545.9, 505.6 in S. B. A.; 587.5, *546.5*, (509) in EtOH (632.4, 583.3, 541.5 with alkali) (155).

$C_{22}H_{14}O_6$.—1, 8-Diacetoxynaphthacenequinone: 571, 328 in S. B. A.; 400 in EtOH (476, 382 with NaOEt) (41).

$C_{22}H_{15}NO_4$.—1-Benzoylamino-4-methoxyanthraquinone (Algol Scarlet G, C. I. 1129): 490, 460 in C_9H_7N; 597, 530, 500 in H_2SO_4 (116).

$C_{24}H_{14}N_2O_5$.—1-Hydroxy-2 (?)-nitro-6 (?)-anilinonaphthacenequinone: 588, 297 in S. B. A.; 610, 575 in EtOH (606 with NaOEt) (41).

$C_{24}H_{15}NO_3$.—1-Anilino-6-hydroxynaphthacenequinone: 556, 293 in S. B. A.; 526 in EtOH (613, 568 with NaOEt) (41).

$C_{26}H_{18}N_2O_2$.—1, 4-Dianilinoanthraquinone: 633.4, *577.5*, 533 in H_2SO_4; 521.7, (483) in S. B. A.; *642.4*, 589.6, 545.5 in EtOH (155).

1, 5-Dianilinoanthraquinone: 533 in solid form; 482 in vapor form (340°) (336).

$C_{28}H_8Cl_4O_2$.—4, 5, 4′, 5′-Tetrachloro-*meso*-naphthadianthrone: 610, (564), *518* in H_2SO_4 (113); *cf.* (437).

$C_{28}H_{10}Br_2O_2$.—3, 3′-Dibromo-*meso*-naphthadianthrone: 550 in H_2SO_4 (113).

$C_{28}H_{10}Cl_2O_2$.—3, 3′-Dichloro-*meso*-naphthadianthrone: 254 in H_2SO_4 (113).

4, 4′-Dichloro-*meso*-naphthadianthrone: 591, *521* in H_2SO_4 (113).

$C_{28}H_{12}Br_2O_2$.—3, 3′-Dibromo-*meso*-benzodianthrone: 640 in H_2SO_4 (113).

$C_{28}H_{12}Cl_2O_2$.—3, 3′-Dichloro-*meso*-benzodianthrone: 645 in H_2SO_4 (113).

$C_{28}H_{12}Cl_4O_2$.—1, 5, 1′, 5′-Tetrachlorodianthrone: 546 in H_2SO_4 (113).

4, 5, 4′, 5′-Tetrachlorodianthrone: 567 in H_2SO_4(113).

1, 4, 1′, 4′-Tetrachlorodianthrone: 546 in H_2SO_4 (113).

$C_{28}H_{12}O_2$.—*meso*-Naphthadianthrone: 569, 511 in H_2SO_4 (113).

$C_{28}H_{12}N_2O_2$.—Indanthrene Yellow G (C. I. 1118): 484, 454 in C_9H_7N; 510, 479, 453 in H_2SO_4 (116).

$C_{28}H_{14}Cl_2O_2$.—3, 3′-Dichlorodianthrone: 546, 450 in H_2SO_4 (113).

4, 4′-Dichlorodianthrone: 630, 584 in H_2SO_4 (113).

$C_{28}H_{15}NO_4$.—α, β-Dianthraquinonylamine (Algol Orange R, C. I. 1137): 496 in C_9H_7N (116).

$C_{28}H_{16}O_2$ (?).—Helianthrone: 618, (590) in H_2SO_4 (437).

Dianthrone: 558, (530) in H_2SO_4 (437).

$C_{28}H_{18}N_2O_4$.—1, 4-Dibenzoyldiaminoanthraquinone (Algol Red 5G, C. I. 1131): 541, 502 in C_9H_7N; 571, 530, 491 in H_2SO_4 (116).

$C_{28}H_{18}N_2O_5$.—1, 5-Dibenzoyldiamino-8-hydroxyanthraquinone (Algol Red R, C. I. 1133): 560.2, (521.4), 488.4 in S. B. A. (190); 562, 524, 492 in C_9H_7N; 610, 568, 526 in H_2SO_4 (116).

$C_{28}H_{22}N_2O_5S$.—1-*p*-Toluido-4-*o*-sulfo-*p*-toluidoanthraquinone: 649.7, 591 in H_2SO_4; *643.8*, 586.5, 540.3, 500, 469.5 in S. B. A.; *650.7*, 596.1, 552.2 in EtOH (155).

$C_{28}H_{22}N_2O_2$.—1, 4-Di-*o*-toluidoanthraquinone: 634.4, *578.2*, 533.4 in H_2SO_4; (618, 600.2), (567, 551.5), (523, 512.8) in S. B. A.; *638.7*, 585.7, 543.1 in EtOH (155).

1, 4-Di-*p*-toluidoanthraquinone: *632.7*, 578.2, 533 in H_2SO_4; *618.3*, 567, 522.4 in S. B. A.; *644.1*, 590.9, 546.5 in EtOH (155).

1, 5-Di-*p*-toluidoanthraquinone: 482 in vapor form (370°) (336).

$C_{29}H_{16}N_2O_5$.—1, 1′-Dianthraquinonylurea: 265 in H_2SO_4 (40).

1, 2′-Dianthraquinonylurea: 260 in H_2SO_4 (40).

2, 2′-Dianthraquinonylurea (C. I. 1138): 410, 270 in H_2SO_4 (40).

$C_{30}H_{12}Br_2O_2$.—Dibromopyranthrone (Indanthrene Scarlet G, C. I. 1098): 509, 478, 449 in C_9H_7N; 538 in H_2SO_4 (116).

$C_{30}H_{14}O_2$.—Pyranthrone (Indanthrene Gold Orange G, C. I. 1096): 486 in C_9H_7N; 620, 575, 545, 504 in H_2SO_4 (116); 544.3, 503.5 in vat (190).

$C_{30}H_{16}O_4$.—2, 2′-Dianthraquinonylethylene (Anthraflavone, C . I. 1095): 581, 548 in H_2SO_4 (116).

$C_{30}H_{18}N_2O_4$.—*N*-Dimethylindanthrene (C. I. 1108): Algol Blue K, 700 in xylene (190).

$C_{30}H_{28}N_4O_2$.—Tetramethyl-*p*-diamino-1, 4-dianilinoanthraquinone: *628.8*, 575, 530.7 in H_2SO_4; *619.5*, 568.2, 524 in S. B. A. (155).

$C_{31}H_{18}N_2O_4$.—β-Anthraquinone-α-anthra-*N*-methylpyridoneamine (Algol Red B, C. I. 1155): 555, 521, 488 in C_9H_7N; 530, 493, 460 in H_2SO_4 (116); 524.8, 490.5, 457.8 in S. B. A. (190).

$C_{34}H_{14}Cl_2O_2$.—Dichloroisoviolanthrone (C. I. 1104): Indanthrene Violet 2R, 594, 545, 505 in C_9H_7N (116).

$C_{34}H_{16}O_2$.—Violanthrone (Indanthrene Dark Blue BO, C. I. 1099): 578.3, 535.6, 500.8 in vat (190); Violanthrene B, 618, 568, 523, 488 in C_9H_7N; 575, 531, 524 in H_2SO_4 (116).

Isoviolanthrone (Indanthrene Violet R, C. I. 1103): 603, 555, 516, 482 in C_9H_7N; 520, 490 in H_2SO_4 (116).

$C_{42}H_{20}Cl_2N_2O_6$.—Dichloro-di-α-anthraquinonyl-2, 7-diaminoanthraquinone (Indanthrene Bordeaux B, C. I. 1143): 540, 500 in C_9H_7N; 580 in H_2SO_4 (116).

$C_{42}H_{22}N_2O_6$.—Di-α-anthraquinonyl-2, 6-diaminoanthraquinone (Indanthrene Red G, C. I. 1140): *641*, 587, 543.2, 497.7 in H_2SO_4 (190); 530, 500 in C_9H_7N (116).

2, 7-Di-α-anthraquinonyldiaminoanthraquinone (Indanthrene Red R, C. I. 1142): 520, 500 in C_9H_7N (116); 525 on cotton (522).

$C_{44}H_{26}N_2O_8$.—4, 4′-Dimethoxy-di-α-anthraquinonyl-2, 6-diaminoanthraquinone (Algol Bordeaux 3B, C. I. 1141): 668, 540, 500 in C_9H_7N; 606, 572 in H_2SO_4 (116); *608.5*, 538.5 in S. B. A. (190).

Algol Brown B (C. I. 1166): 581, 536 in C_9H_7N (113).

Algol Corinth (C. I. 1144): 606, 561 in C_9H_7N; 603, 552 in H_2SO_4 (116).

Algol Gray B (C. I. 1145): 642, 547 in C_9H_7N; 615, 562 in H_2SO_4 (116).

Alizarin Blue S 5R: 540 in H_2O (concd.), 560 (dil.) (269).

Alizarin Red W: 610, 559, 518 in alk. EtOH (369).

Cibanone Brown B (C. I. 1171): 568, 528, 488 in C_9H_7N; 581, *543*, (493) in H_2SO_4 (116).

Cibanone Brown G: 570, 530, 493 in C_9H_7N; 581, *530*, (490) in H_2SO_4 (116).

Cibanone Yellow R (C. I. 1170): 530.6, 492.6 in H_2SO_4 (190); *cf.* (116).

Helindone Orange GRN (C. I. 1147): 490 in C_9H_7N (116).

Indanthrene Blue GED: 650 on cotton (522).

Indanthrene Brown B (C. I. 1120): 614, 557 in C_9H_7N (116).

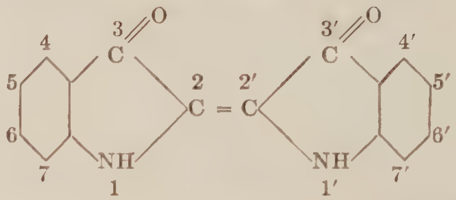
Indanthrene Gray: 530, 490 in C_9H_7N (116).

Indanthrene Maroon R (C. I. 1125): 553, 493 in C_9H_7N (116).

Indanthrene Orange RT (C. I. 1157): 557, 492 in H_2SO_4 (116).

Indanthrene Violet RT (C. I. 1100): 601, *554*, 511 in C_9H_7N; 575, 531, 524 in H_2SO_4 (116); *583.2*, 539.7, 500 in xylene (190).

TABLE 11.—INDIGO DERIVATIVES AND RELATED COLORING MATTERS



$C_{13}H_{11}NO_3$.—2-Indole-3-pentanoneindigo: 478 in $CHCl_3$ (254).

$C_{14}H_{10}N_2O_4S_2$.—Disulfurylindigo: 460, 288 in HOAc; 455 in H_2SO_4 (382).

$C_{15}H_{10}N_2O_3S$.—Sulfurylindigo: 456, *254* in EtOH (633, 288 with alkali); 472 in H_2SO_4 (382).

$C_{16}H_2Br_8N_2O_2$.—Octabromoindigo: 611.5 in xylene; 613.5 in tetralin (154).

$C_{16}H_2Cl_8N_2O_2$.—Octachloroindigo: 606.9, 555.4 in xylene; 604.3, 555.2 in methyl benzoate (191); *cf.* (194).

$C_{16}H_4Br_6N_2O_2$.—4, 5, 7, 4′, 5′, 7′-Hexabromoindigo: 616.2 in xylene; 623.6 in $CHCl_3$ (189); 619 in tetralin (154).

$C_{16}H_5Br_5N_2O_2$.—4, 5, 7, 5′, 7′-Pentabromoindigo: 615 in xylene; 621.3 in $CHCl_3$ (189); 618 in tetralin (154).

$C_{16}H_6Br_2Cl_2N_2O_2$.—5, 5′-Dibromo-4, 4′-dichloroindigo (C. I. 1189): 612.5 in xylene (191); 631.3 in methyl benzoate (194); 615.5 in tetralin (154).

7, 7′-Dibromo-5, 5′-dichloroindigo: 611.5 in xylene; 614.5 in tetralin (154).

$C_{16}H_6Br_2O_2S_2$.—5, 5′-Dibromothioindigo (C. I. 1208): *555.5*, 513.8 in xylene (190); 564, 522, 486, 455 in C_9H_7N (116); *559*, 515 in tetralin (154).

6, 6′-Dibromothioindigo: *539.5*, 498 in xylene; *541.5*, 500 in tetralin (154).

$C_{16}H_6Br_3NO_2S$.—2-(5, 7-Dibromoindole)-5′-bromo-2′-thionaphtheneindigo (C. I. 1222): 598, 557 in C_9H_7N; 550 in H_2SO_4 (116); *590*, 545 in xylene; *592.5*, 547.5 in tetralin (154).

2-(4, 5, 7-Tribromoindole)-2′-thionaphtheneindigo; *585.5*, 539.5 in xylene; *588*, 542 in tetralin (154).

$C_{16}H_6Br_4N_2O_2$.—5, 7, 5′, 7′-Tetrabromoindigo (C. I. 1184): 623 in $CHCl_3$ (350); 620 in $C_6H_5NO_2$ (87); 613 in xylene; 616 in tetralin (154); *cf.* (188, 191). (Ciba Blue 2B reported as 653, 600.5 in xylene (190).)

5, 7, 5′, 7′-Tetrabromoindirubin (C. I. 1205): 579.5, 537 in xylene (190); 590, 545 in C_9H_7N; 580 in H_2SO_4 (116); 613 in xylene; 616 in tetralin (154).

$C_{16}H_6Cl_2O_2S_2$.—4, 4′-Dichlorothioindigo: *545*, 503 in xylene; *547.5*, 505 in tetralin (154).

5, 5′-Dichlorothioindigo (C. I. 1209): *547.3*, 504 in xylene (190); 556, 511 in C_9H_7N (116); *550.5*, 507.5 in tetralin (154).

6, 6′-Dichlorothioindigo (C. I. 1210): Ciba Red B, *539*, 497.5 in xylene; *541*, 499.5 in tetralin. Helindone Rose R, *538*, 497 in xylene; *540*, 499 in tetralin (154).

$C_{16}H_6Cl_4N_2O_2$.—4, 7, 4′, 7′-Tetrachloroindigo: 596.7, 546.8 in xylene; 600.6, 551.7 in methyl benzoate (191).

5, 7, 5′, 7′-Tetrachloroindigo (C. I. 1190): 609 in xylene; 616.6 in methyl benzoate (191); *cf.* (194); 615 in $C_6H_5NO_2$ (87); 613.5 in tetralin (154).

$C_{16}H_7Br_2NO_2S$.—2-(5-Bromoindole)-5′-bromo-2′-thionaphtheneindigo (C. I. 1221); 600, 556 in C_9H_7N (116); *589*, 544.5 in xylene; 591.5, 547 in tetralin (154); *cf.* (190).

3- (5, 7-Dibromoindole)-2′-thionaphtheneindigo (C. I. 1226): *543.5*, 502 in xylene; *546*, 504 in tetralin (154). Thioindigo Scarlet G, 500 in C_9H_7N; 580, 500 in H_2SO_4. Ciba Red G, 530, 500 in C_9H_7N (116).

2- (5, 7-Dibromoindole)-2′-thionaphtheneindigo: *584*, 539 in xylene; *586.5*, 541.5 in tetralin (154).

$C_{16}H_7Br_3N_2O_2$.—5, 7, 5′-Tribromoindigo: 608.7 in xylene (188); 612.5 in xylene; 615.5 in tetralin (154).

$C_{16}H_7Br_3N_2O_2S$.—Tribromo-3-indole-2′-(6′-aminothionaphthene)-indigo (Helindone Brown G, C. I. 1227): 540 in H_2SO_4 (116).

$C_{16}H_8BrNO_2S$.—2-(5-Bromoindole)-2′-thionaphtheneindigo (C. I. 1220): *582.5*, 538.5 in xylene; *585*, 541 in tetralin (154). (Ciba Grey G, 598, 548 in C_9H_7N (116).)

$C_{16}H_8Br_2N_2O_2$.—4, 4′-Dibromoindigo: 613 in $C_2H_2Cl_4$ (165).

5, 5′-Dibromoindigo: 621 in $C_2H_2Cl_4$ (165); 605.5 in xylene; 609 in tetralin (154); *cf.* (188, 350).

6, 6′-Dibromoindigo: *591.6*, 536.5 in xylene; 593.5, 554 in methyl benzoate (191); 585 in $C_2H_2Cl_4$ (165); *592*, 550 in tetralin (154); *cf.* (117, 194).

7, 7′-Dibromoindigo: 606 in $C_2H_2Cl_4$ (165).

6, 6′-Dibromoindirubin: 567, 520 in xylene (118).

$C_{16}H_8Br_2N_2O_2S_2$.—5, 5′-Dibromo-6, 6′-diaminothioindigo (C. I. 1215): *519*, 484 in xylene; *521*, 485.5 in tetralin (154).

$C_{16}H_8Br_4N_4O_2$.—5, 7, 5′, 7′-Tetrabromo-6, 6′-diaminoindigo (C. I. 1187): *559*, 523 in xylene; *562.5*, 526 in tetralin (154); 563.3 in methyl benzoate (194); 585.1 in H_2SO_4 (350).

$C_{16}H_8Cl_2N_2O_2$.—6, 6′-Dichloroindigo: 558.5, *518.5* in xylene; 561, *521* in tetralin (154).

$C_{16}H_8I_2N_2O_2$.—6, 6′-Diiodoindigo: 598, 546.5 in xylene; 600.9, 558.1 in methyl benzoate (194).

$C_{16}H_8N_4O_6$.—5, 5′-Dinitroindigo: 585.5 in $CHCl_3$(?) (350).

6, 6′-Dinitroindigo: 635.5 in xylene; 638 in tetralin (154).

$C_{16}H_8N_6O_2(Cl)_2$.—Tetrazoindigo chloride: *565*, 517 in H_2O (115).

$C_{16}H_8O_2S_2$.—Thioindigo: *543.5*, 502 in xylene; *546*, 504 in tetralin (154); 547 in $CHCl_3$ (163); 552, 508 in C_9H_7N (116); 407, 310 in H_2SO_4 (382); *cf.* (111, 167, 169, 190, 524).

$C_{16}H_8O_3S_2$.—Hydroxythioindigo: *539*, (497.5) in xylene (88).

Thioindigo sulfoxide: 520 in xylene (524).

$C_{16}H_8O_4S_2$.—5, 5′-Dihydroxythioindigo: 590 in $C_2H_2Cl_4$ (164).

6, 6′-Dihydroxythioindigo: 560, 520 in H_2SO_4 (164).

Thioindigo sulfone: 500 in xylene (524).

$C_{16}H_8O_5S_2$.—Trihydroxythioindigo: 487.7 in xylene (88).

$C_{16}H_9NO_2S$.—2-Indole-2′-thionaphtheneindigo: *575*, 531.5 in xylene; *577.5*, 533.5 in tetralin (154); 579 in $CHCl_3$ (163); *cf.* (122).

3-Indole-2′-thionaphtheneindigo (C. I. 1225): *544.5*, 507 in xylene; *546*, 504 in tetralin (154); 510 in C_9H_7N; 580 in H_2SO_4 (116); *cf.* (640).

$C_{16}H_{10}N_2O_2$.—Indigo (C. I. 1177): 630 in $C_6H_5NH_2$ (382); 615.9 in HOAc (117); 604.8 in $CHCl_3$ (350); 590.9 in xylene (117); 601.5 in tetralin (154); 472, 300 in H_2SO_4 (382). (Formánek reports band at 637, Krüss at 605.1); 678 in solid form; 546 in vapor at 320° (336); 650 on cotton (522); *cf.* (111, 187, 191, 524, 528q, 602q, 669q).

Indirubin: *561*, 522 in xylene; *564*, 525 in tetralin (154); 544 in HOAc (641); 568, 534 in C_9H_7N (116); 289 in MeOH (108); 492 in vapor form (305°) (336).

Isoindigo: 520, 335, 268 in MeOH (108); 477 in HOAc (641).

$C_{16}H_{10}N_2O_2S_2$.—5, 5′-Diaminothioindigo: 592, 523 (111).

7, 7′-Diaminothioindigo (C. I. 1213): 646 in C_9H_7N; 584, 550 in H_2SO_4 (116).

$C_{16}H_{10}N_2O_5S$.—Indigo-5-sulfonic acid: K salt, 608 in H_2O; 615 in 80% EtOH; 525 in solid form (268q).

$C_{16}H_{10}N_2O_8S_2$.—Indigo-5, 5′-disulfonic acid: K salt, 610 in H_2O; 610 in 80% EtOH (268q); Na salt (C. I. 1180): 612, 289, 252 in H_2O (179q); *cf.* (115q, 268q, 299q, 390q, 391q, 422q).

$C_{16}H_{10}N_2O_{11}S_3$.—Indigo-5, 7, 5′-trisulfonic acid: K salt, 603 in H_2O; 605 in 80% EtOH; 560 in solid form (268q).

$C_{16}H_{10}N_2O_{14}S_4$.—Indigo-5, 7, 5′, 7′-tetrasulfonic acid: K salt, 590 in H_2O; 598 in 80% EtOH (268).

$C_{16}H_{11}N_3O_2$.—5-Aminoindigo: 589 (111).

$C_{16}H_{12}N_4O_2$.—4, 4′-Diaminoindigo: 594 (111).

5, 5′-Diaminoindigo: 588.9 in H_2SO_4 (350); hydrochloride, 623 in H_2O (115).

$C_{17}H_9NO_3$.—2-Indanone-2′-indoleindigo: 508 in $CHCl_3$ (122).

$C_{17}H_{10}N_2O_3$.—2-Isoquinolone-2′-indoleindigo: 584 in $CHCl_3$ (122).

$C_{17}H_{10}N_2O_2S$.—5-Isatinyl-3-phenylrhodanic acid: 430 in HOAc (677).

$C_{17}H_{11}BrN_2O_2$.—5-Bromo-7-methylindirubin (C. I. 1206): *582*, 538 in xylene; *585*, 541 in tetralin (154).

$C_{17}H_{11}NO_2$.—2-Indane-2′-indoleindigo: 492 in $CHCl_3$ (122).

$C_{17}H_{12}N_2O_2$.—*N*-Methylindigo: 635.5 in xylene; 638.5 in tetralin (154); 639.4 in xylene (117).

5-Methylisoindigo: 491 in HOAc (641).

7-Methylisoindigo: 489 in HOAc (641).

5-Methyl-2-indole-3′-indoleindigo: 535 to 544 in HOAc (641).

7-Methyl-2-indole-3′-indoleindigo: 546 in HOAc (641).

5-Methyl-3-indole-2′-indoleindigo: 544, 532 in HOAc (641).

7-Methyl-3-indole-2′-indoleindigo: 546, 528 in HOAc (641).

$C_{18}H_8Br_2N_2O_3S$.—2-Naphthsultam-2-(5′, 7′-dibromoindole)-indigo: *674*, 614 in C_6H_6 (349).

$C_{18}H_9NO_4S_2$.—2-Thionaphthene-2′-naphthsultamquinoneindigo: *590*, 545 in $C_6H_5NO_2$ (168).

$C_{18}H_{10}Br_2O_2S_2$.—6, 6′-Dibromo-4, 4′-dimethylthioindigo (C. I. 1211): *542.5*, 501 in xylene; *545*, 503 in tetralin (154).

$C_{18}H_{10}Cl_2O_2S_2$.—5, 5′-Dichloro-6, 6′-dimethylthioindigo (Helindone Red 3B, C. I. 1212): *562*, 520.7 in xylene (190); 575, 530 in C_9H_7N (116); 560, 540 on cotton (522).

5, 5′-Dichloro-7, 7′-dimethylthioindigo: *565*, 526 in xylene; *567.5*, 528 in tetralin (154).

$C_{18}H_{10}NO_3S$.—2-Naphthsultam-2′-indoleindigo: *655*, 605 in EtOH (168); *664*, 608 in C_6H_6; *665*, 609 in $CHCl_3$; *670*, 614 in $C_6H_5NO_2$ (349).

$C_{18}H_{10}N_2O_6$.—Indigodicarboxylic acid: 648.7 in dil. NH_4OH; 647.9 in dil. NaOH; 649.9 in dil. KOH (350).

$C_{18}H_{10}O_2S_2$.—Dye from oxythionaphthene and glyoxal: *509*, 476 in xylene (167).

$C_{18}H_{11}NO_2$.—2-Naphthalene-2′-indoleindigo: 644, 591 in $CHCl_3$ (163); *cf.* (122).

$C_{18}H_{12}Br_2N_2O_2$.—6, 6′-Dibromo-1, 1′-dimethylindigo: 635 in xylene; 638 in tetralin (154); 638 in xylene (117).

$C_{18}H_{12}Cl_2N_2O_2$.—5, 5′-Dichloro-1, 1′-dimethylindigo: 665 in xylene (117).

$C_{18}H_{12}N_2O_2$.—Dye from indoxyl and glyoxal: *600*, 555 in xylene (167).

$C_{18}H_{12}N_2O_2S$.—5-Isatinyl-3-*p*-tolylrhodanic acid: 433 in HOAc (677).

$C_{18}H_{12}O_4S_2$.—4, 4′-Dimethoxythioindigo: *554*, 504 in $C_2H_2Cl_4$ (164).

5, 5′-Dimethoxythioindigo: 590 in $C_2H_2Cl_4$ (164).

6, 6′-Dimethoxythioindigo: 570, 530 in $C_2H_2Cl_4$ (164).

$C_{18}H_{14}N_2O_2$.—1, 1′-Dimethylindigo: 644.5 in xylene (117); 642 in xylene; 645 in tetralin (154); *cf.* (166).

7, 7′-Dimethylindigo: 603.8 in xylene; 617.7 in HOAc (187); 606.5 in tetralin (154); *cf.* (350, 524).

5, 5′-Dimethylisoindigo: 512 in H_2SO_4 (641).

7, 7′-Dimethylisoindigo: 528 in H_2SO_4 (641).

$C_{18}H_{14}N_2O_4$.—4, 4′-Dimethoxyindigo: 603 in $C_2H_2Cl_4$ (165).

5, 5′-Dimethoxyindigo: 644 in $C_2H_2Cl_4$ (165).

6, 6′-Dimethoxyindigo: 577 in $C_2H_2Cl_4$ (165).

7, 7′-Dimethoxyindigo: 644 in $C_2H_2Cl_4$ (165); 650.8 in $CHCl_3$ (350).

$C_{18}H_9BrO_2S$.—5-Bromo-2-thionaphthene-2′-acenaphthylenindigo: *520.5*, 480.5 in xylene; *533.5*, 483.5 in tetralin (154).

$C_{20}H_{10}O_2S$.—2-Thionaphthene-2′-acenaphthyleneindigo (C. I. 1228): *516.5*, 479 in xylene; *519.5*, 482 in tetralin (154). Ciba Scarlet G, 526, 490, 444 in C_9H_7N. Thioindigo Scarlet 2G, 525, 490 (116); *cf.* (190).

$C_{20}H_{12}O_2S_2$.—Dye from hydroxythionaphthene and maleic dialdehyde: *527*, 484 in xylene (167).

$C_{20}H_{14}Br_2O_4S_2$.—5, 5′-Dibromo-6, 6′-diethoxythioindigo (C. I. 1218): *529*, 490.5 in xylene; *531.5*, 492.5 in tetralin (154); 539, 494 in C_9H_7N; 598, 547, 501 in H_2SO_4 (116).

$C_{20}H_{14}Cl_2O_4S_2$.—4, 4′-Dimethyl-5, 5′-dichloro-7, 7′-dimethoxythioindigo (C. I. 1219): *590.5*, 554 in xylene; *593.5*, 556.5 in tetralin (154).

$C_{20}H_{14}N_2O_4$.—*N*, *N*′-Diacetylindigo: 545 in xylene (524); *cf.* (166).

$C_{20}H_{16}N_4O_4$.—5, 5′-Diacetyldiaminoindigo: (115).

$C_{20}H_{16}O_2S_2$.—4, 7, 4′, 7′-Tetramethylthioindigo: 552, 511 in xylene; *555*, 513 in tetralin (154).

$C_{20}H_{16}O_2S_4$.—6, 6′-Diethylthiothioindigo (C. I. 1216): *534.5*, 494.5 in xylene; 537, 496.5 in tetralin (154). Helindone Scarlet S, 542, 492 in C_9H_7N; 530, 490 in H_2SO_4 (116).

$C_{20}H_{16}O_3S$.—3, 4-Dihydro-2-naphthalene-6′-ethoxy-2′-thionaphtheneindigo: *565*, 525 in $C_6H_5NO_2$ (168).

$C_{20}H_{16}O_4S_2$.—6, 6′-Diethoxythioindigo (C. I. 1217): *518.5*, 485.5 in xylene; *520.5*, 487.5 in tetralin (154). Helindone Orange R, 526, 490 in C_9H_7N; 547 in H_2SO_4 (116).

$C_{20}H_{18}N_2O_2$.—*N*, *N*′-Diethylindigo: 650 in xylene; 653 in tetralin (524); 652.6 in $CHCl_3$ (350); *cf.* (266).

1, 5, 1′, 5′-Tetramethylindigo: 655 in xylene (117).

$C_{21}H_{14}N_2O_4$.—Ethylindigomalonate: 550 in xylene. Benzoyl deriv., 505 in xylene (524).

$C_{22}H_{13}NO_2$.—1-Anthracene-2-indoleindigo: 660 in $C_2H_2Cl_4$ (43).

2-Anthracene-2-indoleindigo: 660, 603 in $C_2H_2Cl_4$ (43).

9-Anthracene-2-indoleindigo: 492 in $C_2H_2Cl_4$ (43).

$C_{22}H_{13}NO_2S$.—2-(*N*-Phenylindole)-2′-thionaphtheneindigo: 535 in H_2SO_4 (?) (166).

3-(*N*-Phenylindole)-2′-thionaphtheneindigo: 500 in H_2SO_4 (?) (166).

$C_{22}H_{13}NO_3$.—5-Hydroxy-2-anthracene-2-indoleindigo: *664*, 606 in $C_2H_2Cl_4$ (43).

$C_{22}H_{14}N_2O_2$.—*N*-Phenylindirubin: 550 in H_2SO_4 (?) (166).

$C_{22}H_{16}O_4$.—*bis*-(4-Methoxynaphthalene)-indigo: 610 in C_6H_6 (185).

$C_{22}H_{18}N_2O_{10}$.—Tetramethoxyindigodicarboxylic acid: *563.3*, 516.2 in H_2SO_4 (350).

$C_{24}H_{12}Br_2N_2O_2$.—Dibromo-*bis*-β-naphthindoleindigo (C. I. 1198): 619.5 in xylene; 623.5 in tetralin (154).

$C_{24}H_{12}O_2S_2$.—*bis*-1, 2-Naphthothiopheneindigo: 565 in $C_2H_2Cl_4$ (169).

bis-2, 1-Naphthothiophenindigo: 577 in $C_2H_2Cl_4$ (169).

bis-2, 3-Naphthothiopheneindigo: 605 in $C_2H_2Cl_4$ (169).

bis-1, 8-Naphthothiopheneindigo: 644 in $C_2H_2Cl_4$ (169).

$C_{24}H_{13}NO_2S$.—Naphthindole-2, 1-naphthothiopheneindigo: 596 in $C_2H_2Cl_4$ (169).

$C_{24}H_{14}N_2O_2$.—*bis*-Naphthindoleindigo: 626 in $C_2H_2Cl_4$ (169).

Ethylindigophenylacetate: 555 in xylene. Benzoyl deriv., 510 in xylene (524).

Dye from oxythionaphthene and terephthalic aldehyde: 488, 457 in C_7H_8 (167).

$C_{24}H_{16}N_2O_2$.—Dye from indoxyl and terephthalic aldehyde: 530, 490 in C_7H_8 (167).

$C_{24}H_{19}N_5O_2$.—Indigoazodimethylaniline: 572 (111).

$C_{25}H_{18}N_2O_3$.—Benzoyl-*o*-tolylindigo: 575 in xylene (524).

$C_{28}H_{18}N_2O_2$.—*N*, *N*′-Diphenylindigo: 630 in H_2SO_4 (?) (166).

$C_{29}H_{18}N_2O_4$.—Ethyl (anhydrophenylacetic acid)-indigomalonate: 555 in xylene (524).

$C_{30}H_{16}N_4O_8$.—*N*, *N*′-Dinitrobenzoylindigo: 570 in xylene (524).

$C_{30}H_{18}N_2O_4$.—*N*, *N*′-Dibenzoylindigo: *578*, 534 in xylene; *580*, 536 in tetralin (154); 575 in xylene (524).

$C_{32}H_{18}N_2O_2$.—Lake Red Ciba B: 555 in xylene (524).

$C_{32}H_{18}N_4O_4Zn$.—"Zinc indigo:" 570 in $CHCl_3$ (?) (353).

$C_{32}H_{26}N_6O_2S_2$.—*bis*-Dimethylanilinedisazothioindigo: 499 (111).

$C_{32}H_{28}N_8O_2$.—*bis*-Dimethylanilinedisazoindigo: 501 (111).

$C_{50}H_{52}N_6O_2$.—Di-(tetramethyldiaminodiphenylmethane)-diindoxyl: *596.4*, 499.3 in H_2O after oxidation in HOAc soln. (540).

$C_{52}H_{56}N_6O_2$.—Di-(tetramethyldiaminodiphenylmethane)-di-*o*-methylindoxyl: *576.3*, 507.4 in H_2O after oxidation in HOAc soln. (540).

Di-(tetramethyldiaminodiphenylmethane)-di-*p*-methylindoxyl: 634.3 in H_2O after oxidation in HOAc soln. (540).

The indigoid dye from α-aminopyridine and $ClCH_2CO_2H$ has a max. at 515 in slightly alk. soln. and "glyoxalin red" a max. at 510 (124). Dye max. in C_9H_7N:—Ciba Red R (C. I. 1229), 529, 491; Ciba Violet R (C. I. 1222, note), 603, 563; Helindone Brown 2R (C. I. 1223), 582, 530, 498; Helindone Brown 5R (C. I. 1224), 584, 532, 496; Helindone Violet B (C. I. 1219), 603 (?), 568; Helindone Violet 2B (C. I. 1219), 607, 562; Helindone Violet BD, 597, 549; Helindone Violet R (C. I. 1219), 574, 531 (116).

Table 12.—Miscellaneous Dyes

$C_6H_3N_3O_7$.—*sym.*-Trinitrophenol (picric acid, C. I. 7): 360 in EtOH; 380 with NaOEt; 380 in piperidine; 520 in benzene and anthracene (27); *cf.* (51q, 332).

$C_{10}H_6N_2O_5$.—2, 4-Dinitro-1-naphthol, Na salt (Martius Yellow, C. I. 9): 445, 399, 379 in H_2O (370); *cf.* (325q, 348q).

$C_{10}H_6N_2O_8S$.—2, 4-Dinitro-1-naphthol-7-sulfonic acid, Na salt (Naphthol Yellow S, C. I. 10): 429, 399, 257 in H_2O (179q); *cf.* (390q, 391q, 420q, 422q).

$C_{10}H_6O_4$.—5, 6-Dihydroxy-1, 4-naphthoquinone (Naphthazarine): 488, 333, 267 in EtOH (394); neutral alkali salt, 627, 569, 309, in concd. H_2SO_4, 548, 505, 325 (443); *cf.* (550); in acetic anhydride with boracetate, 580, 535 (268).

$C_{12}H_4N_7O_{12}.NH_4$.—Hexanitrodiphenylamine, NH_4 salt (Aurantia, C. I. 12): 425 in H_2O (390q); *cf.* (391).

$C_{12}H_7Br_2NO$.—2, 6-Dibromo-*N*-(*p*-hydroxyphenyl)-*p*-quinoneimine: (175q).

$C_{12}H_7Cl_2NO$.—2, 6-Dichloro-*N*-(*p*-hydroxyphenyl)-*p*-quinoneimine: (175q).

$C_{12}H_9NO$.—Indophenol (*N*-(*p*-hydroxyphenyl)-*p*-quinoneimine): 630 in alk. H_2O; 495 in acid H_2O; 645 in alk. EtOH; 505 in acid EtOH (677).

$C_{12}H_{11}N_3$.—Indamine (*p*-aminophenyl-*p*-quinonediimine) (Phenylene Blue): 660 (57); *cf.* (111); indamineazodimethylaniline, 598 (111).

$C_{13}H_9NO_2$.—2, 8-Dihydroxyacridine: 421 in H_2O (57).

$C_{13}H_{10}O_3$.—4, 4′-Dihydroxybenzophenone: 323 (550).

$C_{13}H_{10}O_5$.—3, 3′, 4, 4′-Tetrahydroxybenzophenone: 449, 406 (550).

$C_{13}H_{11}N_3$.—2, 8-Diaminoacridine (Flavine): 427 in H_2O (57).

$C_{14}H_{14}N_2O$.—Phenol blue: (512).

$C_{15}H_{16}N_3(Cl)$.—2, 8-Diamino-3, 7-dimethylacridinium chloride (Acridine Yellow): 457 in H_2O; 463.3 in EtOH; 464 in AmOH (155).

$C_{15}H_{19}N_4(Cl)$.—Toluylene blue: (512).

$C_{16}H_{11}NO_5S$.—*N*-(*p*-Hydroxyphenyl)-2-sulfo-1, 4-naphthoquinoneimine: 500 in neutral or acid H_2O; 625 in alk. H_2O; 510 in EtOH (272); *cf.* (269, 282q).

$C_{16}H_{12}Cl_2N_4O_7S_2$.—Xylene yellow, Na salt (C. I. 639): (600q).

$C_{16}H_{12}N_4O_9S_2$.—Tartrazine, Na salt (C. I. 640): 430, 260 (432); *cf.* (271, 388q, 447q, 600q).

$C_{16}H_{12}N_4O_9S_2$.—*m*-Sulfophenylhydrazone of 1-*m*-sulfophenyl-5-hydroxypyrazol-3-carboxylic acid, Na salt: 434 in H_2O (**297**).

$C_{16}H_{12}O_5$.—Succinylresorcein: 504 in alk. H_2O (**454**).

$C_{16}H_{14}N_4O_4S$.—Flavazin L, Na salt (C. I. 636): (**600**).

$C_{16}H_{20}N_3(Cl)$.—Tetramethylindamine chloride (Bindschedler's Green): 730 in H_2O (**465**); perchlorate in acid EtOH, 640; polyacidic salts (**306**); 656.7 in $CHCl_3$; 669.6 in CS_2; influence of temp. (**57**); *cf.* (**512**).

$C_{17}H_{19}N_2S(Cl)$.—Thiopyronine: *564.5*, 528 in H_2O; *564.3*, 524.2 in EtOH; 564.3, 524.2 in AmOH (**155**).

$C_{17}H_{20}N_2O$.—4, 4′-Tetramethyldiaminobenzophenone (Michler's Ketone): 368 in acid EtOH (**644**); *cf.* (**192, 465**); (*see also 4,* **101**: 1469; 12.)

$C_{17}H_{20}N_3(Cl)$.—2, 8-Tetramethyldiaminoacridinium chloride (Acridine Orange, C. I. 788): *494.4*, 463.9 in H_2O; *490.9*, 459.5 in EtOH; 490.9, 459.5 in AmOH (**155**).

$C_{17}H_{21}N_2(Cl)$.—4, 4′-Tetramethyldiaminobenzhydrol chloride (Michler's hydrol): 603.3 in H_2O; 605 in EtOH (**155**); 610 in acid EtOH (**644**); *cf.* (**111, 463, 465**).

$C_{17}H_{22}N_3(Cl)$.—Auramine (C. I. 655): base, 300 in EtOH (**192**); chloride in H_2O, 365, *315*, 270 (**420q**); *cf.* (**600q**); 265 in H_2SO_4 (**192**); infra-red abs. (**514**); acetate in EtOH, *435*, 375, (310) (**192**); *cf.* (**38**).

$C_{18}H_{10}N_2O_2$.—Triphendioxazine: 504, 470.5 in EtOH; *642.1*, 586, 537.5 in H_2SO_4 (concd.) (**155**).

$C_{18}H_{12}N_4$.—Fluorindine: hydrochloride, 630.1, *578.7*, 534.8, 497.3, 465.9 in EtOH (*619.2*, 570.2, 530.3 with HCl; 576, *532.8*, 495.5 with NH_3) (**155**).

$C_{18}H_{16}N_2O$.—Indophenol P (C. I. 821): (**516**).

$C_{18}H_{19}N_2S(ClO_4)$.—*p*-Dimethylaminobenzylidene-*N*-methylbenzothiazole perchlorate: *528*, 278 in EtOH; *o*-dimethylamino isomer, 478, 341 in EtOH (**348**).

$C_{19}H_{13}N$.—Phenylacridine: 348, 254 in EtOH (or $CHCl_3$); sulfate, 403, 348, *256* in EtOH (**212**).

$C_{19}H_{15}N_3$.—Chrysaniline: various salts (**497**); phosphine (C. I. 793), 481, 366, 280 in EtOH (**421**); 470 in H_2O (concd.); 472 (dil.) (**269**).

$C_{19}H_{21}N_4(Cl)$.—Cyanoacridine Orange (2, 8-dimethylamino-2, 5, 8, 10-tetrahydro-10-methyl-5-acridine nitrile): 585, 540, 280 in EtOH (**221**).

$C_{19}H_{24}N_3O(Cl)$.—Acetylauramine chloride: 350 in alk. H_2O (**192**); 385 in EtOH (**582**).

$C_{20}H_{10}(Fe)N_2O_{10}S_2(Na_2)$.—Naphthol Green (C. I. 5): 700 (**510**); infra-red abs. (**511**); *cf.* (**510**).

$C_{20}H_{12}OS_2$.—Dithiofluoran: 513, 363, 360 in HOAc + EtOH (**442**).

$C_{20}H_{13}NO_4$.—Resorcinolphthalamein: 489 in dil. NH_4OH (**173**).

$C_{20}H_{15}NO_3$.—Phenolphthalamein: 555 in dil. NH_4OH (**173**).

$C_{20}H_{16}N(Cl)$.—*N*-Methylphenylacridine chloride: 436, 348, *265* in $CHCl_3$; 436, 348, *254* in EtOH; iodide in $CHCl_3$, 425, 354, 254 (**212q**); various acid salts (**209**).

$C_{20}H_{23}N_2O_3(Cl)$.—*asym.*-Dimethyl-*m*-aminophenolsuccinein (Rhodamine S, C. I. 743): 540 in H_2O and on wool (**642**).

$C_{20}H_{26}N_3O(I)$.—Acetylmethylauramine iodide: 600 in EtOH (**582**).

$C_{20}H_{27}N_3S$.—Tetraethylindamine sulfide: $ZnCl_2$ double salt, 656.5, 604.2 in EtOH (**5**).

$C_{20}H_{28}N_3(Cl)$.—Tetraethylindamine chloride: 659.4, 605.2 in EtOH; 657.3 in $CHCl_3$; 664.8 in CS_2; 673.9, 615.3 in H_2O (influence of temp.) (**57**).

$C_{21}H_{12}Br_4O_6$.—Tetrabromoresorcinolumbellein: 505 in H_2O + NH_3 (**173**).

$C_{21}H_{16}O_6$.—Resorcinolumbellein: 482 in H_2O + NH_3 (**173**).

$C_{21}H_{18}O_3$.—Phenolcinnamein: 565 in H_2O + NH_3 (**173**).

$C_{21}H_{18}O_5$.—Phenolumbellein: 543 in H_2O + NH_3 (**173**).

$C_{21}H_{20}N_3(Cl)$.—2, 8-Diamino-3, 7-dimethylphenylacridine chloride (Benzoflavine, C. I. 791): 458 in H_2O; 468 in EtOH; 468.8 in AmOH (**155**); *cf.* (**465**).

$C_{22}H_{22}O_7$.—Resorcinolcamphorein: 497.5 in alk. H_2O (**594**).

$C_{22}H_{24}O_4$.—Phenolcamphorein: 518 in alk. H_2O (**594**).

$C_{23}H_{23}N_2(OAc)$.—3, 6-Di-(dimethylamino)-9-phenyl-3-isofluorene: 621 (**111**).

$C_{23}H_{26}N_3O_2S(Cl)$.—Benzenesulfoneauramine chloride: 570 in EtOH (**582**).

$C_{24}H_{15}N_4O_9S_2$.—*p*-Sulfonaphthylhydrazone of 1-*p*-sulfonaphthyl-3-carboxy-5-pyrazolone: Na salt, 480 in H_2O (abs. of 5-sulfonaphthyl deriv. about the same) (**297**).

$C_{24}H_{23}N_3O_2$.—Tetramethylflaveosine: 500.7, *471.3* in H_2O; *500.7*, 471.3 in acid H_2O; 493, *465.7* in EtOH; *494.8*, 462.6 with acid (**155**).

$C_{24}H_{26}N_3O(Cl)$.—Benzoylauramine chloride: 590 in EtOH (**582**).

$C_{24}H_{28}N_4$.—Hexamethylrheonine: 503.2, 473.2 in H_2O; *490.9*, 458.2 in EtOH (**155**); *492.7*, 460.2 in acid EtOH (**193**).

$C_{24}H_{28}O_4$.—*o*-Cresolcamphorein: 532 in alk. H_2O (**594**).

$C_{24}H_{28}N_4O_9S_2$.—Di-(methylisopropyl)-tartrazine: Na salt, 445 in H_2O (**271**).

$C_{25}H_{13}N_7O_{12}$.—1, 3, 6, 8-Tetranitrodinitrodiphenylcarbazine: 539 in alk. EtOH (**304**).

$C_{25}H_{15}N_5O_8$.—1, 3, 6, 8-Tetranitrodiphenylcarbazine: 542 in alk. EtOH (**304**).

$C_{25}H_{16}N_4O_6$.—1, 3, 6-Trinitrodiphenylcarbazine: 555 in alk. EtOH (**304**).

$C_{25}H_{17}N_3O_4$.—3, 6-Dinitrodiphenylcarbazine: 594 in alk. EtOH (**304**).

1 (?), 3-Dinitrodiphenylcarbazine: 572 in alk. EtOH (**304**).

$C_{25}H_{18}N_2O$.—2-Aminodiphenylcarbazone: 595 in EtOH; 591 in MeOH; 512 in Et_2O; 508 in $CHCl_3$; 508 in CS_2; 500 in C_6H_6; 548 in Me_2CO; 564 in C_5H_5N (**305**).

$C_{25}H_{18}N_2O_2$.—3-Nitrodiphenylcarbazine: 560 in alk. EtOH (**304**).

$C_{25}H_{19}N_3O$.—2, 4-Diaminodiphenylcarbazone: 535 in EtOH; 509 in Me_2CO; 495 in Et_2O; 490 in C_6H_6 (**305**).

$C_{28}H_{20}N_4O_6S_4$.—Chloramine yellow, C. I. 814 (Na salt): on wool (**10**).

$C_{28}H_{31}N_3O_2$.—Tetraethylflaveosine; *505.6*, 473.6 in acid H_2O; 492.6, 460.2 in EtOH (*499.7*, 467.5 with acid) (**155**).

$C_{30}H_{31}Br_4N_3O_2$.—Tetrabromotetraethylflaveosine, ethyl ester: *494.8*, 466.3 in H_2O (*495.5*, 467 with acid); *498.2*, 466.8 in EtOH (*500*, 468 with acid) (**155**).

$C_{30}H_{35}N_3O_2$.—Tetraethylflaveosine, ethyl ester: *507.7*, 474 in H_2O (neutral or acid); *501.1*, 467 in EtOH (501.9, 468 with acid) (**155**).

$C_{34}H_{40}N_4(OAc)_2$.—*bis*-Tetramethyldiaminodiphenylcarbinol diacetate: 599 (**111**).

Cyanile green: infra-red abs. (**296**).

Eastman Red Sensitizer No. 700: infra-red abs. (**387**).

Filter Yellow: ultra-violet abs. (**447**).

Immedial Black B: 610, *580* on cotton (**522**).

Immedial Pure Blue (C. I. 201): dyeings, (**522, 627**).

Immedial Purple: *545*, 525 on linen (**522**).

Katigen Green 2S (C. I. 1006): *660*, 540 on cotton (**522**).

Katigen Violet: 565, *540* on cotton (**522**).

Pontachrome Green GLO: 555 in H_2O (concd.), 575 (dil.) (**269**).

Aminopyrazolones: (**123**).

Azomethines: (**30, 468, 469, 471, 475, 521, 542**).

Citraconeins and itaconeins: (**91**).

Dianilides from substituted malachite green leuco bases and dinitrophenylpyridine chloride (**541**).

Diphenylmethane derivatives: (**192, 454, 463, 464, 467, 470, 529, 644**).

Dirosanilides and rosdianilides of β-oxyacrolein and diformaldehydes (539).

Dyes from bromocyanopyridine and secondary amines: (345).

Hydrazones: (29, 32, 53, 256, 360, 380, 434, 531, 597, 598, 618, 619).

Meriquinones: (77).

Nitro- and nitroso-compounds: (27, 51, 221, 222, 224, 333, 424, 447, 467, 468, 469, 470).

Pyronol dyes derived from natural coloring matters: (645).

Pyrrylmethane derivatives: (137, 141, 144, 145, 146, 229, 517, 651).

Substituted chromones: (249).

Succinyl- and glutaryl-fluoresceins and rhodamines: (112).

"Vinylene-homologous" indol and pyrrol dyes: (344).

Table 13.—Natural Coloring Matters

Acacetin: 333, 263; diacetyl deriv., 317 (606); *cf.* (608).

Acaciin: 333, 263 (238); *cf.* (607).

Allochlorophyllan: *655*, 600, 557, 533, 519, 487, 433, 413, (370) in Et_2O (405); *cf.* (292q, 293q, 294q, 412).

Alloporphyrin: 635, (600), 585, 573, *544*, 507 in Et_2O; 623, (597), 578, 568, *534*, *503* in alk. EtOH; chloride, 634, 576, 545, 507 in EtOH (610, (604), *575*, 564, 556, 531 with excess HCl) (61); *cf.* (404).

Apigenidin: (16).

Apigenin: 333, 247 in EtOH (591); *cf.* (240, 590q, 607, 608); 341, 266 in dil. KOH; reduction product, 570 in dil. KOH (644). Trimethylapigenin (606).

Apiin: (240); *cf.* (607).

Aplysia punctata pigment: (499).

Bacteriochlorin: 593 in EtOH (68); *cf.* (478).

Bacterioerythrin: 548, 510, 470 in CS_2 (68).

Bacteriopurpurin: 593, 528, 490, 463 (mixture of bacteriochlorin and bacterioerythrin) (68); *cf.* (478).

Baicalein: 333, 271 in EtOH (589q). Triacetyl deriv., 288, 250 in EtOH (589q).

Baicalin: 286 in EtOH (589q). Tetraacetyl deriv., 300 in EtOH (589q).

Bilirubin: 638 with NH_3 and Zn salts (367); *cf.* (18, 37, 86q, 253q, 515, 585q, 586q, 644, 646q). Copper bilirubin: 666.5 to 635.9 in EtOH with 1% HCl (354). Azo dye with diazoniumacetophenone salts: 522 in EtOH; 639 in KOH (496); (*cf.* *202*, **29**: 411; 00).

Biliverdin: 639 in acid EtOH (367); *cf.* (515, 646q).

Bixin: (402).

Blood: (601q, 599q).

Bone marrow pigment (cattle): 488.8, 459.5, 433.4 in $CHCl_3$ (369).

Bromococcin: (106).

Bromoporphyrin I: 626.1, 570, 530.3, 495.8 in Et_2O (with HOAc); 598.6, 555.5 in 25% HCl (133).

Capsanthin: (673).

Carbon monoxide hemoglobin: 570, 538, *416*, 347 (480q); *cf.* (9q, 24, 78, 109, 232q, 233, 236q, 386, 548, 599q, 672); infra-red abs. (235); influence of temp. (234); action of light (237). [From human blood, 571.0; from *Arenicola*, 569.9 (36).]

Carbon monoxide sulfhemoglobin: (78, 386).

Carminic acid: *544*, *504*, 474 in H_2SO_4; 624, 581, *498*, 466 in S. B. A.; *571*, 530, 492 in alk. H_2O (101); *cf.* (102); influence of temp. (57); ammoniacal carmin, 560, 518 (369); carminic anhydride, 585, 545 in H_2SO_4; 580, 535 in S. B. A.; 580, 545 in dil. KOH (104).

Carotin: 485, 435 in EtOH; 517, 482 in CS_2 (662); 424 in Et_2O (93); 482, 451, 273 in cyclohexane (530q); *cf.* (557q, 558q, 617, 655). Hepatocarotin (95).

Chalkone: 302 in EtOH (also data on hydroxy- and alkyloxy-deriv.) (592).

Chetopterin: (547).

Chlorocruorin: (157).

Chlorocruoroporphyrin: 641, 580, 553, 512 in Et_2O; 614, 559 in HCl (1:2) (158).

Chlorophyll: *670*, (641), 614, 580, (540) in phytol (662); 656.5, 609.5, 537 in EtOH; 662, 607, 534.5 in Me_2CO (252); *cf.* (92, 286, 291q, 386, 404, 647q); infra-red abs., 745 (481); ultra-violet abs., 420, 325 (374); colloidal solutions, 676, 616, 543.5 in EtOH + H_2O (252); *cf.* (662); living leaf, *678*, (643), (616), (581), (543), 513 (662); *675.5*, 615.5, 547 (252); *cf.* (291q, 404, 626q) [*Euglena* (19)]; "crystallized chlorophyll" (ethylchlorophyllide): *665*, 615, (581), (538), (465), (433) in EtOH (652); *cf.* (404).

Chlorophyll A: *662*, 612, 578, (531), (497), 459, 433 in Et_2O (662); 304 (92); colloidal soln., *678*, 626, 588, (544), (500), 461 in H_2O with 1% Me_2CO (662). Hepatochlorophyll A (95).

Chlorophyll B: 663, *643*, 613, 592, (565), (539), (503), *457*, 429 in Et_2O (662); 304 (92). Hepatochlorophyll B: (95).

Chlorophyllan: (292, 293, 294, 398); (*see* Allo- and Neochlorophyllan).

Cholecyanin: 638 (367).

Chromodoris (zebra, etc.) pigment: 620-22 in formaldehyde; 622 in EtOH (83); 620 in alk. H_2O; 629 in acid H_2O (82).

Chrysin: (317), 266 in EtOH; diacetyl deriv., 286, 250 in EtOH (591q); *cf.* (240, 590, 607, 608). Dimethylchrysin: (606).

Coccinone: (100).

Copratin: *545*, 516 with pyridine and hydrazine hydrate (568); *cf.* (573, 577).

Copratoporphyrin: 621.3, (574.5), 566.3, (529.3), 523.8, 493 in Et_2O with little HOAc; 591.5, 548.5 in 25% HCl; 592, 548.3 in H_2SO_4 (576); *cf.* (435, 571, 573, 577, 579). Methyl ester: 620.2, 565.3, 532.8, 498 in $CHCl_3$ (568). Fe complex: (574, 575, 576). Cu complex: (568, 579).

Coproporphyrin: *593.1*, 573.5, *549.9*, 524.5, 509.3 (also 405.4 according to *202*, **126**: 169; 23) in 25% HCl; *617.5*, 565.5, *538.3*, 503.3 in dil. KOH (565); 624, 597, 578, 568, 531, 497 in Et_2O (125); *cf.* (126, 329, 435, 483, 567, 571, 573, 577, 579, 614q). Methyl ester: *622.6*, 597.6, (577.1, 567.6), 532.5, 498.9 in $CHCl_3$ (126); (also 405 (244)); *cf.* (125, 565, 568). Fe complex: (125, 574, 575, 577). Misc. derivs. (126, 579).

Corpus luteum pigment: (principally carotin) (369).

Crenilabrus blue (*Crenilabrus parvo*): (674q).

Cyanidin: 510.5, 269.5 in EtOH (560q); chloride, 545, (286) (608); (549 in EtOH (656)).

Cyanin chloride: 504 in 7% H_2SO_4; K salt (670), 598, 570 in salt soln. (656); *cf.* (608).

Cyanohematin: (634).

Cyanohemochromogen: *568*, 537 (634); *cf.* (570, 572).

Cyanohemoglobin: 551 (373); *cf.* (241q).

Cyanomethemoglobin: 539 (245).

Cyanomyochromogen: 555 (570, 572).

Cytochrome: 604.6, 566.5, *550.2*, (532, 528), 521 (326); *cf.* (119, 327, 573, 670).

Delphinidin: 522.5, 275 in EtOH (560q); *cf.* (477, 660).

Delphinin chloride: 527 in 25% HCl (660).

Dermocybin: (337).

Deuterohemin: 545.6, 516.2 (135).

Deuteroporphyrin: 621.7, 595.7, 576.8, 566.8, 525.9, 494.1 in Et_2O; 592.4, (572.6), 549.3 in 25% HCl (135).

Diazona violacea pigments: green pigment, 620 in CS_2; violet pigment, 611 in ethyl benzoate, 606 in $C_2H_2Cl_4$ (284).

Dopamelanin: no characteristic bands in visible or ultra-violet (46).

Echinochrome (*Arbacia punctulata*): 530, 484 in Et_2O; 550, 530 in EtOH (530, 484 with HCl; 515, 484 with NH_3) (427).

Endothia pigments: (247q); endothine red (549q).

Emodin: 680.7, 626.6 in H_2SO_4 (540.9, 500.4 on dilution) (350); *cf.* (337).

Etiophyllin: (643), (621), (612), *578*, *543*, 498, (470, 458, 446) in Et_2O (662); *cf.* (139).

Etioporphyrin: (646), *622*, 611, 596, 576, 567, 528, *482* in Et_2O (662); Cu salt, *559.7*, 522.7, 483.3 (180); halogen deriv. (148).

Etiouroporphyrin: (and Fe salt) (130).

Etioxanthoporphyrin: ultra-violet abs. (148).

Esculin: infra-red abs. (1.1), 3.9, 8.7μ (296); ultra-violet abs., 340 (428); *cf.* (481).

Flavone: 286, 250 in EtOH (591q); *cf.* (590q, 608); flavone coloring matters from various sources (591q); *cf.* (590q); flavone and flavonol derivs. (239).

Fluorohemin: ethyl derivs. (356).

Fluoromethemoglobin: 612, 494 (631); *cf.* (241q, 548).

Fucoxanthin: 478, 448 in EtOH (662).

Galangin: 366, 265 in EtOH (591q); *cf.* (590q, 608). Trimethylgalangin: (606).

Glaucophyllin: (663), *601*, 554, (521) in EtOH (662).

Green animal coloring matters: (527).

Green pigments of ripe seeds: (386).

Helicorubin: (96).

Hemateric acid (α-hematoporphyroidin): 630.3, (604), 574.4, 540.6, 507 in $CHCl_3$ (566); 601, 555 in H_2SO_4 (571); *cf.* (435, 573, 579, 580); methyl ester (577); metallic complexes (574, 575, 577, 579).

Hematin: 659, 578, 535 in dil. HCl; 616, 568, 540 in alk. H_2O; 632 in EtOH; 630, 540, 502 in acid Me_2CO; 580, 560, 524 in alk. Me_2CO (369); action of light (631): reduced hematin, 583.5, 556 (264); carbon monoxide reduced hematin, 566.5, 530 (264); *cf.* (70q, 368, 480q, 548, 633q); α-hematin: (566, 567, 568, 573, 577).

Hematoporphyrin: 595.5, 573.8, 551.7, 526.3, 514.3, (507.8), 407.5 in 25% HCl (406.5, 390 in dil. acid); 618.5, 566.8, 540.5, 504.5, 461 in dil. KOH; 624, (597), 569, 529, *497*, (471) in Et_2O (657); *cf.* (70q, 121, 186q, 230q, 244, 298, 368, 414, 435, 483q, 505, 548, 566, 567, 571, 573, 577, 599q, 611q, 661, 672, 676); acetyl deriv., 601, 554.5 in H_2SO_4 (578); esters (140, 244, 355, 564, 604q); metallic complexes (263, 453, 574, 575); α-hematoporphyrin: 629, 575, 540, 507 in $CHCl_3$ (566); *cf.* (505, 567, 580).

Hemibilirubin: (371).

Hemin: 612, 567, 390 in dil. alk. H_2O (369); 405 in $CHCl_3$ with NH_3 (414); *cf.* (125, 368, 403, 404, 672); hemin derivatives (184, 355, 356, 357, 358).

Hemochromogen: 558, 526, 385 (369); *cf.* (70q, 94, 237, 263, 368, 548, 614q, 672); derivatives (263, 264, 327, 570).

Hemoglobin: 558, 429 (369); infra-red abs. (235); ultra-violet abs. (538); action of light (237); Hb. of annelids (632q); chlorohemoglobins (639); *cf.* (9q, 15q, 24, 72q, 228q, 251, 263, 295, 328q, 368, 548, 672).

Hemophyllin: (180).

Hemoporphyrin: 592.8, 572.4, 549.7 in 25% HCl; 617.4, 570.5, 539.4, 505, 449 in dil. KOH (125); *cf.* (435, 504, 571); derivatives (139).

Hepato-pancreas pigment of crayfish: secretion gave 560, (596) (372).

Hesperetidin: (16, 17).

Hesperetin: (17).

Hydrobilirubin: 497 in acid H_2O; 508 in EtOH with $ZnCl_2 + NH_3$ (371).

Hypericum red (*Hypericum perforatum*): about 597, 547, 512 in 80% EtOH (75).

Idaeine chloride: 507 in 7% H_2SO_4 (659).

Isocoproporphyrin: 622.8, 597.1, 577.9, 568.2, 527.7, 494.4 in acetic ether; 591.2, 568.4, 547.1, 521.6, 505.9 in 5% HCl (126); β-isocoproporphyrin and various derivatives (126).

Isomesoporphyrin: 622.5, 611.8, 596, 576.4, 567.1, 559.4, 544, 526.8, 494.1, 465 in Et_2O; 589.5, 566.7, 546.9 in 5% HCl; ester and its Cu salt (147).

Isoquercitrin: 362, 263 in EtOH (551).

Isorhamnetin: 374, 255 in EtOH (591q); *cf.* (590q).

Isouroporphyrin: 608.5, 558.2, 537.6, *502.9* in dil. NaOH; 598.2, 576.5, *552.2* in 25% HCl (128); octamethyl ester and Cu salt (128).

Kämmerer's porphyrin: 603, 557, (554) in 25% HCl; 641, 582, 544, 509 in dil. KOH; 633, 578, 567, 533, 498 in Et_2O (125); *cf.* (132, 483q); dimethyl ester (132).

Kämpferide: (590q, 591q, 608). Kämpferol and Kämpferitrin, (607, 608). Trimethylkämpferide (606).

Kémeri's porphyrin: 638, 582, 534, 499 in Et_2O; 595, 556 in 25% HCl (329).

Kermesic acid: 633, 534, *501*, 470 in H_2SO_4; *623*, 576, 529, *493*, 463 in S. B. A.; *567*, *527*, 493 in alk. H_2O (101); *cf.* (99); trimethyl ether, *500*, 540 in H_2SO_4 (99); decarboxy deriv., 567, 527, 490 in alkali; 543, *504*, 474 in H_2SO_4 (101); *cf.* (106).

Lutein: (655); *cf.* (370, 373).

Luteolin: 337, 253 in EtOH (591); *cf.* (590); reduction product (608).

Lycopin: (654).

Malvin: 519, 277.5 in slightly acid EtOH; 451, 389.5, 322 in slightly alk. EtOH (560q).

Mandarin orange peel coloring matter: (330).

Marennin (*Navicula ostrearia*): (47).

Meconium pigment: *539*, 576 in Me_2CO (band develops at 639 on long standing) (367).

Melanins: (171).

Mesobilirubin: Cu salt, 634.7, 580.3 in HOAc (142).

Mesobilirubinogen: (483); condensation product with *p*-dimethylaminobenzaldehyde, 556 (483); condensation product with *p*-nitrobenzaldehyde, 545, 495 in EtOH (141).

Mesobiliviolin: 606.5, 560.6, 498.3 in $CHCl_3$; Zn salt in EtOH, 626, 575, 509 (141).

Mesobiliviolinogen: Zn salt, 556, 489 in EtOH (141).

Mesoporphyrin: 592.7, 572.5, 549.7, 524, 509, 404.7 in 25% HCl; 629, 617, 601, (584, 574.5), (548, 526.5, 506.5) in dil. KOH (563); 623, 598, 579, 569, 528, 495 in Et_2O (125); *cf.* (139, 368, 369, 404, 435, 504, 505, 567, 571, 573, 577, 657, 672); dimethyl ester (139); metallic derivs. (574, 575, 671, 672).

Methemoglobin: 631, 576, 540, 500 in neutral soln. (535); (410) (369); (604), 577.9, 540.6 in alk. soln. (233); (493, 415) (369); action of light (237); Met. Hb. of annelids (632); *cf.* (25, 70q, 73, 109, 227, 241q, 242q, 255, 366q, 368, 435, 548).

Methyl chlorophyllide a: *662*, 612, 578, 532, (500), 458, 432, in Et_2O (662); *641*, 596, (566), 526, 494, 458 in alk. EtOH (663).

Methyl chlorophyllide b: 663, *643*, (614), 593, (566), 539, (504), *456*, 430 in Et_2O (662); 641, 625, 580, (537) in alk. EtOH (663).

Methyl phäophorbide a: *666*, (635), 608, (559), 533, 502, (471) in Et_2O (663).

Methyl phäophorbide b: *656*, 599, 558, 534, 520, (489), (448), *436* in EtOH (663).

Morin: (644); pentamethylmorin (606); morin reduction product, 586 in dil. KOH (644); *cf.* (608).

Muscle pigment: (200).

Mycoporphyrin (*Penicilliopsis clavariaeformis*): (91).

Myochromogen: 549.5, 519 (569, 572).

Myohematin: (569, 572). (Cytochrome.)

Myricetin: 374, 253 in EtOH (591); *cf.* (590q, 607); hexamethylderiv. (606); myricitrin (607); reduction product of myricetin and myricitrin (608).

Myrtillidine chloride: 583 in EtOH (665).

Myrtilline chloride: 517 in 7% H_2SO_4 (665).

Naringenin: (592q, 593).

Naringin: (592q, 593).

Neochlorophyllan: *667*, 606, (559), 532, 496, (471), 411, 393, 371 in Et_2O (405); 668, 607, (563), 537, 506, 414, 399, 374 in $CHCl_3$ (294q); *cf.* (292q).

Nephrorosein: (14).

Nitric oxide hemoglobin: 578.5, 541.8 (233); *cf.* (241q, 242, 548).

Nitrite methemoglobin: (631.1), 577, 539 (233); *cf.* (241q).

Ocrein: (416).

Oenidine chloride: 553 in EtOH (665).

Oenine chloride: 518 in 7% H_2SO_4 (665).

Ooporphyrin: (132, 134, 566); dimethyl ester (125); esters and Fe complexes (132).

Oxyhelicorubin: (96).

Oxyhemocyanin: 571 to 581 in alk. H_2O with samples of different origins; ultra-violet bands at 346, 278 (69); 579, 475 (mollusks); 563, 475 (arthropods) (536).

Oxyhemoglobin: infra-red abs. (235); 577.5, 541.7, 411.5 (562); ultra-violet abs. (251, 417, 480, 507); effect of light (237); influence of temp. (234, 289); action of Cl, etc. (425); effect of phenylhydrazine (373); *cf.* (9q, 71q, 72q, 73q, 89q, 109, 226q, 228, 232q, 233, 236q, 241q, 255q, 368, 369, 414, 548, 599q, 672); of human blood, 576.4; of *Arenicola*, 574.6; of *Nephys*, 575.7 (36): of annelids (632).

Paeonidin: 511, 274 in EtOH (560q).

Papendieck porphyrin (chloroform-soluble): 630, 576, 540.5, 507 in $CHCl_3$; 632, (585, 575.5), 535, 501 in Et_2O; 603.5, 557.5 in 25% HCl (565); *cf.* (132, 503): ester (132).

Parahematins: (327).

Pelargonidine: *504.5*, 450, 400.5, 331, *267* in EtOH (560); chloride (608, 653, 664).

Pelargonine chloride: (608, 653).

Phäophytin: *662*, 607, 561, 533, 501 in Me_2CO; Cu compd., 633, 599, 561 in Me_2CO; Zn compd., 654, 605.5, 564.5, 524 in Me_2CO; (data on colloidal solns.) (252).

Phäophytin component a: *667*, (635), 608, (559), 533, 502, 471 in Et_2O (663).

Phäophytin component b: *656*, 600, 559, 534, 520, (503), *449*, 434 in EtOH (663).

Phonoporphyrin: 593, 573, 549 in 25% HCl; 621, 572, 540, 506 in dil. KOH (125).

Phycocyan: blue violet pigment (*Ceramium rubrum*), *616*, 551 in H_2O: blue pigment (*Phormidium* sp.), *613*, 575 in H_2O; blue green pigment (*Gallaei siridot*), 621 in H_2O (359); *cf.* (331, 365q); *Palmellococcus* (49); *Schizophyces* (48).

Phycoerythrin: (*Ceramium rubrum*), *567*, 539, 495 in H_2O (359); (*Nostoc commune*) (610); (*Phormidium persicinum*) (650); *cf.* (331) (data on ultra-violet abs.) (365q, 545).

Phylloerythrin: (641), 594, *567*, 526 in $CHCl_3$; 620, 611, 570, (536) in HOAc + HCl (613, 567, 525 with zinc acetate) (407); *cf.* (131, 414q).

Phyllohemin: (403); β-phyllohemin, 606.5, 556.5 in H_2SO_4; 556, 549.5, (522) with pyridine and hydrazine hydrate (571).

Phyllophyllin: 594, *583*, *551*, 510, (480) in Et_2O (662).

Phylloporphyrin: 632, 622, (604), 576, 567, 533, 501 in Et_2O; 628, 574, 537, 503 in alk. EtOH; chloride (609), 567, 536, (502) in EtOH (604, *561*, (520) with excess HCl) (658); *cf.* (125, 404q, 563); phylloporphyrin β: 604.5, 556 in H_2SO_4 (571); *cf.* (573).

Phytochlorin e: lactam hydrate, *667*, 609, (558), 531, 500 in Et_2O (662); *664*, 613, 584, 533, (497) in 3% HCl; *662*, 634, 606, 558, 534, 501, 467 in MeOH with 5% KOH (663).

Phytorhodin g: *654*, 599, 562, 527 in Et_2O (662): *647*, 589, 563, 538 in 9% HCl; *653*, 599, 575, (556), 531 in MeOH with 5% KOH (663).

"Porphyrin X:" (435).

Protopelargonidine: 438, 481 in pH 5 to 6 soln., 538 in alk. soln. (477).

Protoporphyrin: 604, 581.4, *558.2* in 25% HCl (abs. of dimethyl ester and metallic complexes also given) (143).

Pyocyaneus pigments: ultra-violet abs. (551).

Pyrrole black: (171).

Pyrrophyllin: (620), *582*, 542, 503 in EtOH (662).

Pyrroporphyrin: (650), 622, 597, 568, 525, (498, 492, 487) in Et_2O; 621, (596), (575, 567), 529, 497 in alk. EtOH: chloride (620), 599, 568, 560, 552, 529, 496 in EtOH (600, (569, 560, 552), 527 with excess HCl) (658); *cf.* (125).

Quercetin: 375, 258 in EtOH (551); *cf.* (590q, 591q, 607, 608, 644); quercitrin, (607, 608); quercimeritrin (550); reduction products (608, 644); pentamethylquercetin (606); pentaacetylquercetin (591).

Resoapigenidin: 465; 489 in pH 5 to 6 soln.; 540 in alk. soln. (477).

Resochrysinidin: 435; 487 in pH 5 to 6 soln. (477).

Rhizostoma cuvieri pigment (zoocyanin): 640, *590*, 560 (675).

Rhodochlorogen (Hawaiian *Dioscorea*): 520 in acetic ether (38).

Rhodophyllin: *599*, 554, (516) in EtOH (662); 584, 545, (505) in alk. EtOH (661).

Rhodoxanthin: (479).

Rutin: 363, 263 in EtOH (552); reduction product (608).

Sakuranetidin: (16).

Saproporphyrin D: 624.2, 568.8, 527, 496 in Et_2O; 597.5, 552 in H_2SO_4 (578).

Schizoneura lanigera pigment: 651, 589, 571, 543, 526, 504, 478 in Et_2O (561).

Schizophyceae phycoerythrin: (48, 49).

Scutellarein (and scutellarin): (240, 589q).

Selenohemoglobin: (78).

Shikizarin: 480, 333, 281, 250 in EtOH (394).

Shikonin: 513, 282 in EtOH (394).

Skatol red: (285).

Stercobilin: (34).

Stick lac: (615); *cf.* (102).

Sulfhematin: (634).

Sulfhemoglobin: 623, (579, 542), 423 in H_2O (369); *cf.* (386, 548).

Syringidin: 520, 273.5 in EtOH (560).

Thujorhodin: (616).

Turacin: 565, 528 in H_2O with NH_3 (129); *cf.* (327).

Urinary pigments: pathological pigment (364): pigment isolated with *p*-dimethylaminobenzaldehyde (attributed to skatoxyl) (553).

Urobilin: 495 in EtOH; 510 in EtOH with $ZnCl_2$; 511 in alk. H_2O; 496 in acid H_2O (371); *cf.* (198, 373, 672); urobilinogen: (483q).

Uroerythrin: (50).

Uroporphyrin: *596.7*, 577, *553.4*, 526.3, 511.8 in 25% HCl; *611.3*, 559.3, *538.4*, 501.8 in dil. KOH (565); 600, 555.5 in H_2SO_4 (571); *cf.* (125, 435, 577); methyl ester, *625*, 599, (581.5, 570.5), 536, 499.5 in $CHCl_3$ (565); 408 (244); *cf.* (125, 577); metallic salts (125, 126, 575).

Urorosein: (14, 285).

Vegetable oils: cottonseed (526q); *cf.* (415); sesame (415); *cf.* (52); soya bean (526); misc. (415).

Visual purple: 503 in H_2O; 511 in the rods; 540 (corr.) in the cones (248); 565, 530, 500 (630).

Wogonin: 286 in EtOH; acetylwogonin, 290, 248 in EtOH (589q).

Worm porphyrin: 607, 571, 544 in HOAc; 629, 579, 539, 504 in Et_2O (125).

Xanthophyll: 475, 445, 419 in Et_2O (93); 478, 448 in EtOH; 508, 476 in CS_2 (662); *cf.* (558q, 655); hepatoxanthophyll (95).

Zooerythrin: (537).

The greater part of the tabulated data on chlorophyll derivatives was taken from the work of Willstätter and his collaborators. The following references to the work of Marchlewski and his collaborators may also prove of interest: (**397, 400, 401, 404, 406, 410, 411, 414**).

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(90) Davis and Sheard, *562*, **40**: 226; 27. (91) Dhar and Dutt, *482*, **4**: 253; 27. (92) Dhéré and Rogowski, *34*, **155**: 653; 12. (93) Dhéré and Ryneki, *34*, **157**: 501; 13. (94) Dhéré and Vegezzi, *34*, **163**: 209; 16. (95) Dhéré and Vegezzi, *34*, **163**: 399; 16. (96) Dhéré and Vegezzi, *34*, **164**: 869; 17. (97) Dieterle and Stegemann, *293*, **264**: 1; 26. (98) Dilthey, *52*, **109**: 273; 25. (99) Dimroth, *25*, **43**: 1387; 10.

(100) Dimroth, *13*, **399**: 1; 13. (101) Dimroth and Fick, *13*, **411**: 315; 16. (102) Dimroth and Goldschmidt, *13*, **399**: 62; 13. (103) Dimroth and Hilken, *25*, **54**: 3050; 21. (104) Dimroth and Kämmerer, *25*, **53**: 471; 20. (105) Dimroth and Ruck, *13*, **446**: 123; 25. (106) Dimroth and Scheurer, *13*, **399**: 43; 13. (107) Dimroth, Schultze and Heinze, *25*, **54**: 3035; 21. (108) Dornier and Martinet, *27*, **33**: 779; 23. (109) Doumer and Fourrier, *206*, **93**: 1364; 25.

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(120) Everest and McCombie, *4*, **99**: 1752; 11. (121) Fabre, *34*, **181**: 623; 25. (122) Felix and Friedländer, *57*, **31**: 55; 10. (123) Fierz-David, *Künstliche organische Farbstoffe.* Berlin, 1926. (124) Finger and Kraft, *25*, **57**: 1950; 24. (125) Fischer, H., in Oppenheimer, *Handbuch der Biochemie.* Jena, 1923. (126) Fischer, H., and Andersag, *13*, **458**: 117; 27. (127) Fischer, H., and Beller, *13*, **444**: 238; 25. (128) Fischer, H., and Heisel, *13*, **457**: 83; 27. (129) Fischer, H., and Hilger, *202*, **138**: 49; 24.

(130) Fischer, H., and Hilger, *202*, **140**: 223; 24. (131) Fischer, H., and Hilmer, *202*, **143**: 1; 25. (132) Fischer, H., and Kögl, *202*, **138**: 262; 24. (133) Fischer, H., and Kotter, *25*, **60**: 1861; 27. (134) Fischer, H., and Lindner, *202*, **142**: 141; 25. (135) Fischer, H., and Lindner, *202*, **161**: 17; 26. (136) Fischer, H., and Meyer, *202*, **75**: 339; 11. (137) Fischer, H., and Meyer-Betz, *202*, **75**: 232; 11. (138) Fischer, H., and Meyer-Betz, *57*, **59**: 799; 12. (139) Fischer, H., and Müller, *202*, **142**: 120; 25.

(140) Fischer, H., and Müller, *202*, **142**: 155; 25. (141) Fischer, H., and Niemann, *202*, **137**: 293; 24. (142) Fischer, H., and Niemann, *202*, **146**: 196; 25. (143) Fischer, H., and Pützer, *202*, **154**: 39; 26. (144) Fischer, H., and Schubert, *25*, **56**: 1202; 23. (145) Fischer, H., and Schubert, *25*, **56**: 2379; 23. (146) Fischer, H., and Schubert, *25*, **57**: 610; 24. (147) Fischer, H., and Treibs, *13*, **450**: 132; 26. (148) Fischer, H., and Treibs, *13*, **457**: 209; 27. (149) Fischer, O., *52*, **98**: 204; 18.

(150) Fischer, O., and Scheibe, *52*, **100**: 86; 20. (151) Formánek, *563*, **2**: 171; 03. (152) Formánek, *563*, **2**: 473; 03. (153) Formánek, *563*, **4**: 33; 05. (154) Formánek, *Chem. obzor*, **3**: 133; 28. (155) Formánek and Grandmougin, *Untersuchung und Nachweis organischer Farbstoffe auf spektroskopischem Wege*, Part I, Berlin, 1908. (156) Formánek and Knop, *91*, **56**: 273; 17. (157) Fox, H., *5B*, **99**: 199; 26. (158) Fox, H., *58*, **117**: 49; 26. (159) Fox, J., *4*, **97**: 1337; 10.

(160) Fox, J., *4*, **101**: 1498; 12. (161) French, *45*, **18**: 298; 26. (162) French, *559*, **2**: 124; 27. (163) Friedländer, *25*, **41**: 772; 08. (164) Friedländer, *25*, **49**: 955; 16. (165) Friedländer, Bruckner and Deutsch, *13*, **388**: 23; 12. (166) Friedländer and Kunz, *25*, **55**: 1597; 22. (167) Friedländer and Risse, *25*, **47**: 1919; 14. (168) Friedländer and Sander, *25*, **57**: 637; 24. (169) Friedländer and Woroshov, *13*, **388**: 1; 12.

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(180) Gnehm, *52*, **76**: 401; 07. (181) Gnehm, *52*, **76**: 471; 07. (182) Gnehm and Kaufler, *25*, **37**: 3032; 04. (183) Gnehm and Rübel, *52*, **64**: 497; 01, (184) Goldman, *205*, **172**: 127; 26. (185) Gorke, Köpper and Staiger, *25*, **41**: 1156; 08. (186) Goto, *205*, **135**: 329; 23. (187) Grandmougin, *25*, **42**: 4218; 09. (188) Grandmougin, *25*, **42**: 4408; 09. (189) Grandmougin, *25*, **43**: 937; 10.

(190) Grandmougin, *136*, **34**: 1076; 10. (191) Grandmougin, *34*, **173**: 1363; 21. (192) Grandmougin and Favre-Ambrumyan, *25*, **47**: 2127; 14. (193) Grandmougin and Lang, *25*, **42**: 3631; 09. (194) Grandmougin and Seyder, *25*, **47**: 2365; 14. (195) Graves and Adams, *1*, **45**: 2439; 23. (196) Grebe, *7*, **10**: 673; 92. (197) Gsell, *91*, **55**: 417; 16. (198) Guigues, *345*, **16**: 86; 09. (199) Gulik, *8*, **46**: 147; 15.

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(210) Hantzsch, *25*, **42**: 2129; 09. (211) Hantzsch, *25*, **43**: 2512; 10. (212) Hantzsch, *25*, **44**: 1783; 11. (213) Hantzsch, *9*, **18**: 470; 12. (214) Hantzsch, *25*, **46**: 1537; 13. (215) Hantzsch, *25*, **48**: 158; 15. (216) Hantzsch, *25*, **48**: 167; 15. (217) Hantzsch, *25*, **49**: 511; 16. (218) Hantzsch, *25*, **52**: 509; 19. (219) Hantzsch, *25*, **54**: 2573; 21.

(220) Hantzsch and Glover, *25*, **39**: 4153; 06. (221) Hantzsch and Hein, *25*, **52**: 493; 19. (222) Hantzsch and Korczynski, *25*, **42**: 1217; 09. (223) Hantzsch and Lifschitz, *25*, **45**: 3011; 12. (224) Hantzsch and Lister, *25*, **43**: 1685; 10. (225) Hantzsch and Robertson, *25*, **43**: 106; 10. (226) Hari, *205*, **82**: 229; 17. (227) Hari, *205*, **103**: 271; 20. (228) Hari, *205*, **115**: 52; 21. (229) Hari, *205*, **117**: 41; 21.

(230) Hari, *205*, **135**: 344; 23. (231) Hartley, *4*, **51**: 152; 87. (232) Hartridge, *289*, **44**: 1; 12. (233) Hartridge, *289*, **54**: 253; 21. (234) Hartridge, *289*, **54**: (Proc. cxxviii); 21. (235) Hartridge and Hill, *289*, **48**: (Proc. li); 14. (236) Hartridge and Roughton, *289*, **64**: 405; 28. (237) Hasselbalch, *205*, **19**: 435; 09. (238) Hattori, *558*, **2**: 99; 25. (239) Hattori, *558*, **4**: 41; 28.

(240) Hattori, *558*, **4**: 63; 28. (241) Haurowitz, *202*, **138**: 68; 24. (243) Haurowitz, *202*, **151**: 130; 26. (244) Hausman and Krumpel, *205*, **186**: 203; 27. (245) Havas, *25*, **47**: 994; 14. (246) Havas and Bernhard, *25*, **46**: 2723; 13. (247) Hawkins and Stevens, *Am. J. Bot.*, **4**: 336; 17. (248)

Hecht and Williams, *223*, **5**: **1**; 22. (249) Heilbron, Barnes and Morton, *4*, **123**: 2559; 23.

(250) Heilbron, Holt and Kitchen, *4*, **1928**: 934. (251) Henri and Wurmser, *206*, **72**: 1039; 12. (252) Herlitzka, *55*, **11**: **171**; 12. (253) Herzfeld, *202*, **77**: 280; 12. (254) Herzog and Jolles, *25*, **48**: 1574; 15. (255) Heubner and Rosenberg, *205*, **38**: 345; 12. (256) Hewitt, Johnson and Pope, *4*, **105**: 364; 14. (257) Hewitt, Lewcock and Pope, *4*, **101**: 604; 12. (258) Hewitt, Mann and Pope, *4*, **105**: 2193; 14. (259) Hewitt and Mitchell, *4*, **91**: 1251; 07.

(260) Hewitt and Thole, *4*, **97**: 511; 10. (261) Hewitt and Thomas, *4*, **95**: 1292; 09. (262) Hildebrand, *9*, **14**: 349; 08. (263) Hill, *230*, **19**: 341; 25. (264) Hill, *5B*, **100**: 419; 26. (265) Holmes, *560*, **13**: 6; 23. (266) Holmes, *560*, **13**: 54; 23. (267) Holmes, *45*, **15**: 833; 23. (268) Holmes, *1*, **46**: 208; 24. (269) Holmes, *45*, **16**: 35; 24.

(270) Holmes, *1*, **46**: 627; 24. (271) Holmes, *1*, **46**: 631; 24. (272) Holmes, *1*, **46**: 2770; 24. (273) Holmes, *45*, **17**: 59; 25. (274) Holmes, *45*, **17**: 918; 25. (275) Holmes, *1*, **49**: 790; 27. (276) Holmes, *483*; **16**: 429; 27. (277) Holmes, *559*, **3**: 45; 28. (278) Holmes and Hann, *559*, **3**: 122; 28. (279) Holmes and Scanlan, *1*, **49**: 1594; 27.

(280) Holmes and Snyder, *1*, **47**: 221; 25. (281) Holmes and Snyder, *1*, **47**: 226; 25. (282) Holmes and Snyder, *1*, **47**: 2232; 25. (283) Holmes and Snyder, *1*, **50**: 1907; 28. (284) Holt, *5B*, **88**: 227; 14. (285) Homer, *141*, **22**: 345; 12. (286) Houstoun, *8*, **21**: 535; 06. (287) Howe, *2*, **8**: 674; 16. (288) Howe and Gibson, *2*, **10**: 767; 17. (289) Hüfner, *202*, **58**: 39; 08.

(290) Hüttig, *7*, **87**: 129; 14. (291) Iwanowski, *Ber. botan. Ges.*, *25*: 416; 07. (292) Jacobson, *1*, **34**: 1266; 12. (293) Jacobson and Marchlewski, *205*, **39**: 174; 12. *1*, **47**: 221; 25. (294) Jacobson and Marchlewski, *205*, **40**: 296; 12. (295) Jirgensons, *205*, **194**: 140: 28. (296) Johnson, J. and Spence, *2*, **5**: 349; 15. (297) Johnson, M., *54*, **40**: 176; 21. (298) Kajdi, *205*, **165**: 475; 25. (299) Kalandek, *63*, **9**: 128; 08.

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(310) Kehrmann and Hempel, *25*, **50**: 856; 17. (311) Kehrmann, Robert and Sandoz, *25*, **49**: 2831; 16. (312) Kehrmann and Sandoz, *25*, **50**: 1667; 17. (313) Kehrmann and Sandoz, *25*, **50**: 1673; 17. (314) Kehrmann and Sandoz, *25*, **51**: 915; 18. (315) Kehrmann and Sandoz, *25*, **51**: 923; 18. (316) Kehrmann and Sandoz, *37*, **1**: 270; 18. (317) Kehrmann and Sandoz, *37*, **3**: 104; 19. (318) Kehrmann and Sandoz, *25*, **53**: 63; 20. (319) Kehrmann and Sandoz, *37*, **4**: 31; 21.

(320) Kehrmann and Sandoz, *37*, **5**: 895; 22. (321) Kehrmann and Sandoz, *37*, **6**: 982; 23. (322) Kehrmann and Sandoz, *37*, **8**: 250; 25. (323) Kehrmann, Speitel and Grandmougin, *25*, **47**: 2976; 14. (324) Kehrmann, Speitel and Grandmougin, *25*, **47**: 3205; 14. (325) Kehrmann, Speitel and Grandmougin, *25*, **47**: 3363; 14. (326) Keilin, *5B*, **98**: 312; 25. (327) Keilin, *5B*, **100**: 129; 26. (328) Kennedy, *131*, **79**: 346; 27. (329) Kémeri, *205*, **151**: 438; 25.

(330) Kimura and Nakamura, *437*, **1**: 41; 22. (331) Kitasato, *558*, **2**: 75; 25. (332) Knoblauch, *8*, **43**: 739; 91. (333) Koch, *8*, **32**: 167; 87. (334) Koenigsberger and Kilching, *8*, **28**: 889; 09. (335) Koenigsberger and Kilching, *8*, **32**: 843; 10. (336) Koenigsberger and Küpferer, *8*, **37**: 601; 12. (337) Kögl and Postowsky, *13*, **444**: 1; 25. (338) Kögl and Taeuffenback, *13*, **445**: 170; 26. (339) König, *52*, **88**: 193; 13.

(340) König, *25*, **55**: 3293; 22. (341) König, *25*, **56**: 1543; 23. (342) König, *25*, **57**: 685; 24. (343) König, *25*, **57**: 891; 24. (344) König, *92*, **38**: 743; 25. (345) König and Becker, *52*, **85**: 353; 12. (346) König and Meier, *52*, **109**: 324; 25. (347) König and Müller, *25*, **57**: 144; 24. (348) König and Treichel, *52*, **102**: 63; 21. (349) König and Wagner, *25*, **57**: 1057; 24.

(350) Krüss, G., *7*, **2**: 312; 88. (351) Krüss, G., *7*, **18**: 559; 95. (352) Krüss, P., *7*, **51**: 257; 05. (353) Kunz, *25*, **55**: 3689; 22. (354) Küster, *202*, **149**: 30; 25. (355) Küster and Heess, *25*, **58**: 1022; 25. (356) Küster and Neunhöffer, *202*, **172**: 179; 27. (357) Küster and Ruff, *202*, **151**: 98; 26. (358) Küster and Zimmermann, *202*, **153**: 125; 26. (359) Kylin, *202*, **76**: 396; 12.

(360) Lankshear and Lapworth, *4*, **99**: 1785; 11. (361) Lasareff, *8*, **24**: 661; 07. (362) Lasareff, *8*, **37**: 812; 12. (363) Lasareff, *7*, **100**: 266; 22. (364) Lehmann and Zinn, *Berl. klin. Wochschr.*, **47**: 2244; 10. (365) Lemberg, *13*, **461**: 46; 28. (366) Letsche, *202*, **80**: 412; 12. (367) Lewin, *278*, **145**: 393; 12. (368) Lewin, Miethe and Stenger, *34*, **143**: 115; 06. (369) Lewin, Miethe and Stenger, *278*, **118**: 80; 07.

(370) Lewin, Miethe and Stenger, *278*, **124**: 585; 08. (371) Lewin and Stenger, *278*, **144**: 279; 12. (372) Lewin and Stenger, *278*, **178**: 80; 20. (373) Lewin and Stenger, *99*, **21**: 221; 22. (374) Lewkowitsch, *230*, **22**: 777; 28. (375) Ley, *25*, **50**: 243; 17. (376) Ley, *7*, **94**: 405; 20. (377) Ley and Engelhardt, *25*, **41**: 2509; 08. (378) Leyko and Marchlewski, *205*, **22**: 464; 09. (379) Liebermann, *25*, **21**: 2527; 88.

(380) Lifschitz, *25*, **47**: 1401; 14. (381) Lifschitz, *25*, **52**: 1919; 19. (382) Lifschitz and Laurié, *25*, **50**: 897; 17. (383) Lipmaa, *34*, **182**: 867; 26. (384) List, *202*, **138**: 164; 24. (385) Llemura and Tabei, *41B*, **3**: 105; 28. (386) Long and Spriggs, *Quart. J. Med.*, **11**: 102; 18. (387) Lubimenko, *34*, **142**: 1432; 06. (388) Lubovitch and Peaven, *69*, **16**: 195; 22. (389) Lund, *1*, **49**: 1346; 27.

(390) Lunelund, *60*, **59A**: No. 21; 16. (391) Lunelund, *60*, **60A**: No. 12; 17. (392) Lunelund, *60*, **62A**: No. 5; 19. (393) Macbeth and Maxwell, *4*, **123**: 370; 23. (394) Majima and Kuroda, *558*, **1**: 43; 22. (395) Maki, *43*, **11**: 1; 20. (396) Maki, *142*, **27**: 1; 24. (397) Malarski and Marchlewski, *205*, **21**: 523; 09. (398) Malarski and Marchlewski, *205*, **24**: 319; 10. (399) Malarski and Marchlewski, *205*, **27**: 246; 10.

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(410) Marchlewski and Robel, *205*, **32**: 204; 11. (411) Marchlewski and Robel, *25*, **45**: 816; 12. (412) Marchlewski and Marszalek, *205*, **35**: 413; 11. (413) Marchlewski and Moroz, *27*, **35**: 37; 24. (414) Marchlewski and Moroz, *27*, **35**: 705; 24. (415) Marcille, *Ann. fals.*, **30**: 423; 10. (416) Marino-Zuco and Foa, *36*, **41**: 331; 11. (417) Mashimo, *429*, **2**: 199; 17. (418) Massol and Faucon, *27*, **13**: 217; 13. (419) Massol and Faucon, *27*, **13**: 513; 13.

(420) Massol and Faucon, *27*, **13**: 700; 13. (421) Massol and Faucon, *27*, **13**: 803; 13. (422) Mathewson, *J. Assoc. Off. Agr. Chem.*, **2**: 164; 16. (423) Mathewson, *45*, **12**: 883; 20. (424) Mathewson, *J. Assoc. Off. Agr. Chem.*, **6**: 16; 22. (425) Mayer and Vlés, *561*, **2**: 96; 20. (426) Mazzucchelli, *22*, **23**: 953; 14. (427) McClendon, *141*, **11**: 435; 12. (428) McLennan and Cole, *5*, **102**: 256; 23. (429) Medhi and Watson, *4*, **107**: 1579; 15.

(430) Meek, *4*, **111**: 969; 17. (431) Meek and Watson, *4*, **109**: 544; 16. (432) Mees and Clark, *45*, **11**: 454; 19. (433) Mellon and Martin, *50*, **31**: 161; 27. (434) Merriman, *4*, **103**: 1845; 13. (435) Mertens, *202*, **167**: 179; 27. (436) Meuly, *Diss.*, Weide, 1923. (437) Meyer, H., Bondy and Eckert, *75*, **121**: 1011; 12. (438) Meyer, K., *25*, **41**: 2568; 08. (439) Meyer, K. and Hantzsch, *25*, **40**: 3479; 07.

(440) Meyer, M., *25*, **47**: 1161; 14. (441) Meyer, R., and Fischer, *25*, **44**: 1944; 11. (442) Meyer, R., and Fischer, *25*, **46**: 70; 13. (443) Meyer, R., and Fischer, *25*, **46**: 85; 13. (444) Meyer, R., and Marx, *25*, **40**: 3603; 07. (445) Meyer, R., and Marx, *25*, **41**: 2446; 08. (446) Miethe, *317*, **26**: 54; 03. (447) Miethe and Stenger, *99*, **19**: 57; 19. (448) Mills, *4*, **121**: 455; 22. (449) Mills and Braunholtz, *4*, **123**: 2804; 23.

(450) Mills and Odams, *4*, **125**: 1913; 24. (451) Mills and Raper, *4*, **127**: 2466; 25. (452) Milroy, *289*, **38**: 384; 09. (453) Milroy, *230*, **12**: 318; 18. (454) Moir, *557*, **7**: 5; 18. (455) Moir, *557*, **7**: 111; 18. (456) Moir, *557*, **7**: 123; 18. (457) Moir, *557*, **7**: 183; 19. (458) Moir, *557*, **8**: 41; 19. (459) Moir, *557*, **8**: 42; 19.

(460) Moir, *557*, **8**: 225; 20. (461) Moir, *557*, **8**: 303; 20. (462) Moir, *557*, **9**: 129; 21. (463) Moir, *557*, **9**: 205; 21. (464) Moir, *557*, **10**: 35; 22. (465) Moir, *557*, **10**: 65; 22. (466) Moir, *557*, **10**: 159; 22. (467) Moir, *557*, **10**: 233; 22. (468) Moir, *557*, **10**: 273; 22. (469) Moir, *4*, **121**: 1555; 22.

(470) Moir, *557*, **11**: 91; 23. (471) Moir, *4*, **123**: 2792; 23. (472) Moir, *4*, **127**: 2338; 25. (473) Moir, *557*, **13**: 131; 26. (474) Moir, *4*, **1927**: 1809. (475) Moir, *557*, **14**: 301; 27. (476) Moir, *557*, **14**: 233; 27. (477) Moir, *557*, **16**: 121; 28. (478) Molisch, *Die Purpurbacterien*. Jena, 1907. (479) Monteverde and Luybimenko, *134*, **7**: 1105; 13.

(480) Newcomer, *141*, **37**: 465; 19. (481) Nichols and Merritt, *2*, **19**: 18; 04. (482) Nichols and Merritt, *2*, **31**: 376; 10. (483) Niemann, *202*, **146**: 181; 25. (484) Oesterle and Tisza, *293*, **245**: 534; 07. (485) Okunev, *205*, **193**: 70; 28. (486) Orndorff and Allen, *1*, **37**: 1244; 15. (487) Orndorff and Barnett, *1*, **46**: 2483; 24. (488) Orndorff and Hitch, *1*, **36**: 707; 14. (489) Orndorff, Gibbs and McNulty, *1*, **47**: 2767; 25.

(490) Orndorff, Gibbs and McNulty, *1*, **48**: 1994; 26. (491) Orndorff, Gibbs, McNulty and Shapiro, *1*, **49**: 1545; 27. (492) Orndorff, Gibbs, McNulty and Shapiro, *1*, **49**: 1541; 27. (493) Orndorff, Gibbs and Shapiro, *1*, **48**: 1327; 26. (494) Orndorff, Gibbs and Shapiro, *1*, **50**: 819; 28. (495) Orndorff and McNulty, *1*, **49**: 1588; 27. (496) Orndorff and Teeple, *1*, **33**: 215; 05. (497) Ostwald, *7*, **9**: 579; 92. (498) Ostwald, *287*, **10**: 179; 19. (499) Paladino, *Beitr. chem. Physiol. Path.*, **11**: 65; 08.

(500) Palkin, *45*, **15**: 379; 23. (501) Palkin and Wales, *1*, **46**: 1488; 24. (502) Palkin and Wales, *1*, **47**: 2005; 25. (503) Papendieck, *202*, **140**: 16; 24. (504) Papendieck, *202*, **152**: 215; 26. (505) Papendieck and Bonath, *202*, **144**: 60; 25. (506) Partos, *205*, **105**: 49; 20. (507) Peyrega and Vlés, *34*, **154**: 133; 12. (508) Pflüger, *8*, **65**: 173; 98. (509) Pflüger, *8*, **12**: 430; 03.

(510) Pfund, *172*, **20**: 279; 12. (511) Pfund, *99*, **12**: 341; 13. (512) Phillips, Clark and Cohen, *231*, **Suppl. No. 61**: 27. (513) Phillips and Goss, *1*, **48**: 823; 26. (514) Piccard, *1*, **48**: 2352; 26. (515) Piettre, *34*, **146**: 786; 08. (516) Pihlblad, *7*, **81**: 417; 12. (517) Pilotty, Stock and Dorman, *25*, **47**: 1124; 14. (518) Plaats, *8*, **47**: 429; 15. (519) Plotnikow, *7*, **79**: 357; 12.

(520) Pope, *4*, **93**: 532; 08. (521) Pope and Willett, *4*, **103**: 1258; 13. (522) Porai-Koschitz and Auschkap, *Z. Farben-Ind.*, **10**: 321; 11. (523) Porai-Koschitz, Auschkap and Amsler, *53*, **43**: 1587; 11. (524) Posner, *25*, **59**: 1799; 26. (525) Prideaux, *The theory and use of indicators.* London, 1917. (526) Priest, *348*, **3**: 37; 20. (527) Przibram, *278*, **153**: 385; 13. (528) Pulfrich, *8*, **14**: 177; 81. (529) Pummerer, Eckert and Gassner, *25*, **47**: 1494; 14.

(530) Pummerer and Rebmann, *25*, **61**: 1099; 28. (531) Purvis, *4*, **97**: 2535; 10. (532) Purvis, *4*, **105**: 590; 14. (533) Purvis, *4*, **107**: 660; 15. (534) Purvis and McCleland, *4*, **101**: 514; 12. (535) Quagliariello, *Arch. sci. biol.*, **3**: 65; 22. (536) Quagliariello, *Pubbl. staz. zool. Napoli, Ric. fisiol. chim. biol.*, **1**: 57; 22. (537) Regnier, *206*, **95**: 77; 26. (538) Reinhard, *223*, **11**: 1; 27. (539) Reitzenstein and Bönitsch, *52*, **86**: 1; 12.

(540) Reitzenstein and Breuning, *13*, **372**: 257; 10. (541) Reitzenstein and Schwerdt, *52*, **75**: 369; 07. (542) Reitzenstein and Stamm, *52*, **81**: 150; 10. (543) Robertson, *4*, **103**: 1473; 13. (544) Robertson and Brady, *4*, **103**: 1479; 13. (545) Rodio, *22*, **1**: 188; 25. (546) Rohn, *8*, **38**: 987; 12. (547) Romieu and Obata, *34*, **175**: 51; 22. (548) Rost, Franz and Heise, *291*, **31**: 223; 09. (549) Sando, *Am. J. Botany*, **6**: 242; 19.

(550) Sando, *141*, **68**: 407; 26. (551) Sando and Bartlett, *141*, **54**: 629; 22. (552) Sando and Lloyd, *141*, **58**: 737; 24. (553) Scheff, *205*, **168**: 451; 26. (554) Scheibe, *25*, **56**: 137; 23. (555) Scheibe and Fischer, *25*, **59**: 502; 26. (556) Scheibe and Rossner, *25*, **56**: 137; 23. (557) Schertz, *341*, **26**: 383; 23. (558) Schertz, *341*, **30**: 253; 25. (559) Schneider and Kunzl, *Z. Mikroskopie*, **23**: 394; 06.

(560) Schou, *37*, **10**: 907; 27. (561) Schultz, *205*, **127**: 112; 22. (562) Schumm, *202*, **83**: 1; 13. (563) Schumm, *202*, **90**: 1; 14. (564) Schumm, *202*, **132**: 34; 24. (565) Schumm, *202*, **136**: 243; 24. (566) Schumm, *202*, **139**: 219; 24. (567) Schumm, *202*, **147**: 221; 25. (568) Schumm, *202*, **149**: 1; 25. (569) Schumm, *202*, **149**: 111; 25.

(570) Schumm, *202*, **150**: 276; 25. (571) Schumm, *202*, **152**: 1; 26. (572) Schumm, *202*, **152**: 55; 26. (573) Schumm, *202*, **152**: 147; 26. (574) Schumm, *202*, **153**: 225; 26. (575) Schumm, *202*, **156**: 268; 26. (576) Schumm, *202*, **159**: 194; 26. (577) Schumm, *202*, **164**: 143; 27. (578) Schumm, *202*, **169**: 52; 27. (579) Schumm and Mertens, *202*, **156**: 61; 26.

(580) Schumm and Papendieck, *202*, **159**: 190; 26. (581) Scott and French, *Military Surgeon*, Sept., 1924. (582) Semper, *13*, **381**: 234; 11. (583) Shaeffer, Paulus and Jones, *1*, **37**: 776; 15. (584) Shapiro, *1*, **50**: 1772; 28. (585) Sheard, Baldes, Mann and Bollman, *131*, **76**: 577; 26. (586) Sheard, Mann and Bollman, *131*, **81**: 774; 27. (587) Sheppard, *204*, **48**: 300; 08. (588) Sheppard, *5*, **82**: 256; 09. (589) Shibata, *558*, **1**: 106; 23.

(590) Shibata and Kimotsuki, *41*, **39**: 771; 18. (591) Shibata and Kimotsuki, *558*, **1**: 91; 23. (592) Shibata and Nagai, *41*, **43**: 101; 22. (593) Shibata and Nagai, *558*, **2**: 25; 24. (594) Singh, Rai and Lal, *4*, **121**: 1421; 22. (595) Sircar, *4*, **109**: 757; 16. (596) Smith and Boord, *1*, **44**: 1449; 22. (597) Stevens and Ward, *4*, **125**: 1324; 24. (598) Stobbe and Nowak, *25*, **46**: 2887; 13. (599) Strub, *99*, **24**: 97; 26.

(600) Stumpf, *99*, **20**: 183; 21. (601) Suhrmann and Kollath, *205*, **184**: 216; 27. (602) Svedberg and Pihlblad, *7*, **74**: 513; 10. (603) Szceniovski, *165.* **1927A**: 127. (604) Szilárd, *205*, **170**: 185; 26. (605) Tasaki, *558*, **2**: 49; 25, (606) Tasaki, *558*, **2**: 119; 25. (607) Tasaki, *558*, **2**: 129; 25. (608) Tasaki, *558*, **3**: 1; 27. (609) Tasaki, *558*, **3**: 21; 27.

(610) Teodoresco, *34*, **163**: 62; 16. (611) Téthi, *205*, **192**: 105; 28. (612) Thiel and Dassler, *25*, **56**: 1667; 23. (613) Thiel, Dassler and Wülfken, *237*, **18**: No. 3; 24. (614) Treibs, *202*, **168**: 68; 27. (615) Tschirch and Ludy, *37*, **6**: 994; 23. (616) Tswett, *34*, **152**: 788; 11. (617) Tswett, *Ber. botan. Ges.*, **29**: 630; 11. (618) Tuck, *4*, **91**: 449; 07. (619) Tuck, *4*, **95**: 1809; 09.

(620) Uemura and Tabei, *41B*, **2**: 229; 27. (621) Uemura and Tabei, *41B*, **2**: 249; 27. (622) Uemura, Yokojima and Endo, *41B*, **2**: 10; 27. (623) Uemura, Yokojima and Endo, *41B*, **2**: 48; 27. (624) Uemura, Yokojima and Tan, *41B*, **1**: 260; 26. (625) Unger and Hofmann, *25*, **29**: 1362; 96. (626) Ursprung, *Ber. botan. Ges.*, **36**: 73; 18. (627) Uspenski and Woronkoff, *96*, **17**: 112; 23. (628) Vaillant, *34*, **184**: 939; 27. (629) Vaillant, *51*, **8**: 391; 27.

(630) Venable, *48*, **10**: 133; 25. (631) Ville and Derrien, *34*, **140**: 1195; 05. (632) Vlès, *34*, **169**: 303; 19. (633) Vlès, *561*, **2**: 125; 20. (634) Vlès, *561*, **2**: 223; 20. (635) Vlès, *34*, **185**: 644; 27. (636) Vlès and Gex, *34*, **185**: 946; 27. (637) Vogel, *8*, **43**: 449; 91. (638) Vogt, *7*, **132**: 101; 28. (639) Volta and Viterbi, *Boll. soc. ital. biol. sper.*, **2**: 431; 27.

(640) Wahl and Bagard, *27*, **15**: 336; 14. (641) Wahl and Faivret, *14*, **5**: 314; 26. (642) Wales, *1*, **45**: 2420; 23. (643) Wales and Palkin, *1*, **48**: 810; 26. (644) Watson and Meek, *4*, **107**: 1567; 15. (645) Watson, Sen and Medhi, *4*, **107**: 1477; 15. (646) Weber, *Z. biol. Tech. Methodik*, **2**: 29; 10. (647) Weigert, *25*, **49**: 1496; 16. (648) Wick, *2*, **24**: 356; 07. (649) Willgerodt and Maffezzoli, *52*, **82**: 205; 10.

(650) Wille, *Ber. botan. Ges.*, **40**: 188; 22. (651) Willstätter and Asahina, *13*, **385**: 188; 11. (652) Willstätter and Benz, *13*, **358**: 267; 08. (653) Willstätter and Bolton, *13*, **408**: 42; 15. (654) Willstätter and Escher, *202*, **64**: 47; 10. (655) Willstätter and Escher, *202*, **76**: 214; 12. (656) Willstätter and Everest, *13*, **401**: 189; 13. (657) Willstätter and Fischer, *202*, **87**: 423; 13. (658) Willstätter and Fritzsche, *13*, **371**: 33; 09. (659) Willstätter and Mallison, *13*, **408**: 15; 15.

(660) Willstätter and Mieg, *13*, **408**: 61; 15. (661) Willstätter and Pfannenstiel, *13*, **358**: 205; 08. (662) Willstätter and Stoll, *Untersuchungen über Chlorophyll.* Berlin, 1913. (663) Willstätter, Stoll and Utzinger, *13*, **385**: 156; 11. (664) Willstätter, Zechmeister and Kindler, *25*, **57**: 1938; 24. (665) Willstätter and Zollinger, *13*, **408**: 83; 15. (666) Winther, *9*, **19**: 389; 13. (667) Wise and Adams, *45*, **10**: 801; 18. (668) Wise and Adams, *45*, **11**: 460; 19. (669) Wolff, *91*, **17**: 65; 78.

(670) Yaoi and Tamiya, *543*, **4**: 436; 28. (671) Zaleski, *25*, **46**: 1687; 13. (672) Zaleski, *53*, **48**: 1337; 16. (673) Zechmeister and Cholnoky, *13*, **454**: 54; 27. (674) Zeynek, *75*, **121**: 1495; 12. (675) Zeynek, *75*, **121**: 1539; 12. (676) Zilner, *205*, **192**: 118; 28. (677) Holmes, *0*.

VISCOSITY OF PURE LIQUIDS

F. GIORDANI

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Units.—All values of the viscosity, η, are expressed in poises. The values tabulated are those of 100η which are equivalent to values of η expressed in centipoises.

Unités.—Toutes les valeurs de la viscosité, η, sont exprimées en poises. Les valeurs mentionnées dans les tables sont celles de 100η qui sont équivalentes aux valeurs de η exprimées en centipoises.

Einheiten.—Alle Werte der Viskosität, η, sind in C. G. S.-Einheiten ausgedrückt. Die in Zahlentafeln stehen Werte gelten für 100η und entsprechen den Werten von η, die in Hundert-C. G. S.-Einheiten gegeben sind.

Unità.—Tutti i valori della viscosità, η, sono espressi in poise. I valori nelle tabelle sono quelli di 100η che sono equivalenti al valore di η espresso in centipoise.

𝔄-TABLE, ELEMENTARY SUBSTANCES

$$100\eta_t = \frac{a}{1 + 10^{-3}bt + 10^{-6}ct^2}$$

Br_2 (84)

t, °C	100η
−2.6	1.287*
+7	1.136
13.6	1.058
19.5	0.995
27	0.925
31.4	0.901
−4.3	1.311†
+4.9	1.164
12.6	1.071
19.1	1.003

a = 1.241
b = 12.257
c = 8.721

* Purified with KOH.

† Prepared from pure KBr.

Cl_2 (84)

t, °C	100η
−76.5	0.729
−74	0.710
−70.5	0.680
−65.8	0.649
−65.4	0.646
−60.2	0.616
−60	0.610
−53	0.569
−52.4	0.566
−45.1	0.530
−44.1	0.524
−35.4	0.494
−33.8	0.489

a = 0.385
b = 5.878
c = −3.92

H_2 (94)

t, °C	100η
−252.57	0.0130

I_2 (84)

t, °C	100η
116	2.268
116.6	2.246
121.9	2.157
122.8	2.180
128.7	2.080
136.1	1.979
142.7	1.870
147.8	1.822
149	1.813
152.5	1.770
157.7	1.716
158.9	1.688
169.8	1.572
171.4	1.545
178.7	1.462

a = 9.68
b = 21.833
c = 52.01

O_2 (96%) (95)

t, °C	100η
−252.07	0.189

S (37)

t, °C	100η
123	10.94
135.5	8.66
149.5	7.09
156.3	7.19
158.8	7.59
159.2	9.48
159.5	14.45
160	22.83
160.3	77.32
165	500
171	4 500
184	16 000
190.5	19 700
197.5	21 300
200	21 500
210	20 500
217	19 100
222	18 600

(8)

t, °C	100η
121	9.94
	9.92 *
	11.4 †
	10.2_7 ‡

* After 1 hour standing at 121°.

† After many hours standing at 200° and subsequent cooling to 121°.

‡ After further standing 1 hour at 121°.

𝔅-TABLE, STANDARD ARRANGEMENT (*v.* Vol. III, p. viii)

H_2O

v. Vol. V, p. 10

SO_2 (38)

t, °C	100η
−33.5	0.5508
−10.5	0.4285
0.1	0.3936

H_2SO_4

v. Vol. V, p. 11

N_2O_4 (91)

t, °C	100η
0.72	0.5220
5.09	0.4954
9.15	0.4720
11.87	0.4578
15.36	0.4401

$$\eta_t = \frac{28.155}{(140.89 + t)^{1.7349}}$$

NH_3

t, °C	100η
−33.5	0.254 (34)
−33.5	0.266 (38)

NOCl (15)

t, °C	100η
−33.3	0.642
−29.5	0.604
−27	0.586
−25.2	0.567
−20	0.547

$SbBr_3$ (57)

t, °C	100η
95	3.3_1
100	3.1_2

$BiCl_3$ (4)

t, °C	100η
260	32.0
270	29.5
280	27.0
290	25.0
300	23.0
310	21.5
320	20.5
330	19.0
340	18.0

CO_2

v. Vol. V, p. 11

For other C-compounds, *v.* the ℭ-Table *infra*

$SnCl_4$ (56)

t, °C	100η
25	0.91_9
30	0.80_6
40	0.72_5
50	0.66_8
70	0.60

$PbCl_2$ (63)

t, °C	100η
498	5.53
508	5.06
518	4.66
528	4.30
538	4.02
548	3.78
558	3.59
568	3.42
578	3.28
588	3.16
598	3.06
608	2.95

$PbBr_2$ (63)

t, °C	100η
372	10.2
382	8.80
392	8.06
402	7.47
412	6.97
422	6.53
432	6.13
442	5.74
452	5.38
462	5.03
472	4.70
482	4.38
492	4.07

$HgBr_2$ (8)

t, °C	100η
240	3.31
247	2.97
258	1.97

HgI_2 (8)

t, °C	100η
258	3.54

AgCl (62)

t, °C	100η
603	1.60
632	1.46
669	1.37
734	1.18

AgBr (62)

t, °C	100η
609	1.86
649	1.66
688	1.49
770	1.22
803	1.19

AgI (62)

t, °C	100η
605	3.02
611	2.85
630	2.75
698	2.37
730	2.12
792	1.85
806	1.68
827	1.55

$AgNO_3$ (40)

t, °C	100η
244	3.77
265	3.27
275	3.04
309	2.61
342	2.29

B_2O_3 (2)

t, °C	100η
750	43 600
800	26 000
850	17 000
900	11 800
950	9 000
1 000	7 000
1 050	5 300
1 100	4 000

$LiNO_3$ (40)

t, °C	100η
259	5.58
269	5.10
274	4.85
284	4.50
310	3.69
317.5	3.49
319	3.48
320	3.47

NaOH (3)

t, °C	100η
350	4.0
400	2.8
450	2.2
500	1.8
550	1.5

NaCl (61)

t, °C	100η
841	1.30
850	1.20
896	1.01
924	0.97

NaBr (61)

t, °C	100η
762	1.42
766	1.35
780	1.28

$NaNO_3$ (63)

t, °C	100η
308	2.92
318	2.78
328	2.66
338	2.54
348	2.44
358	2.33
368	2.24
378	2.14
388	2.06
398	1.98
408	1.90
418	1.83

(40)

t, °C	100η
337	2.53
353	2.29
356	2.28
385.2	1.99
406	1.77
495	1.32

$NaPO_3$ (2)

t, °C	100η
650	1250
700	700
750	440
800	300
850	210

KOH (3)

t, °C	100η
400	2.3
450	1.7
500	1.3
550	1.0
600	0.8

KCl (61)

t, °C	100η
790	1.42
835	1.21
920	0.99
1035	0.71

KBr (61)

t, °C	100η
745	1.48
775	1.34
805	1.19

KNO_3 (63)

t, °C	100η
333	2.97
343	2.83
353	2.69
363	2.56
373	2.44
383	2.33
393	2.21
403	2.11
413	2.01

(40)

t, °C	100η
347	2.79
371	2.35
377	2.29
396	2.14
418	1.89
462	1.58
506	1.34

$K_2Cr_2O_7$ (63)

t, °C	100η
397	13.4
407	12.6
417	11.8
427	11.2
437	10.6
447	9.9
457	9.4
467	8.8
477	8.2
487	7.7
497	7.1
507	6.6

ℭ-TABLE; ℭ-ARRANGEMENT (*v.* Vol. III, p. viii)

A, B, n are the coefficients in the formula $\eta = \frac{A}{(B + t)^n}$

CCl_4 (91), Carbon tetrachloride

t, °C	100η	t, °C	100η
0.60	1.3322	42.08	0.7198
7.15	1.8884	49.51	0.6567
14.89	1.0476	56.29	0.6078
21.21	0.9517	62.87	0.5659
27.56	0.8705	69.89	0.5246
35.21	0.7855	74.16	0.5017

A = 32.780
B = 95.05
n = 1.7121

(60)

t, °C	100η
25	0.8876

CS_2 (91)

Carbon disulfide

t, °C	100η
0.4	0.428
4.88	0.413
9.45	0.397
14.91	0.381
19.94	0.367
25.34	0.356
30.30	0.342
35.51	0.328
40.60	0.317
45.96	0.306

A = 24.379
B = 199.17
n = 1.6328

$CHBr_3$

Bromoform

(8)	
6.4	2.381
(20)	
10	2.217
76.5	1.009

$CHCl_3$

Chloroform
v. Vol. V, p. 11

HCN (102)

Hydrogen cyanide

−7.5	0.259
+5.0	0.232
10.8	0.218
15.1	0.211
20.2	0.201

CH_2Br_2 (26)

Methylene bromide

25	0.1225

CH_2Cl_2 (91)

Methylene chloride

0.46	0.5329
5.73	0.5023
10.18	0.4794
15.45	0.4545
20.53	0.4330
25.59	0.4137
30.98	0.3933
37.51	0.3707

A = 5.8768
B = 128.88
n = 1.4408

CH_2O_2 (91); *cf.* (10, 68, 82)

Formic acid

7.59	2.385
15.96	1.951
24.16	1.635
32.86	1.379
40.36	1.208
48.03	1.064
56.30	0.937
64.20	0.838
72.05	0.754
80.22	0.681
97.23	0.558

CH_2O_2.—(*Cont'd*)

A = 32.8143
B = 59.799
n = 1.7164

CH_3I (91); *cf.* (39)

Methyl iodide

t, °C	100η
0	0.593
0.42	0.5914
6.06	0.5576
10.53	0.5330
15.81	0.5064
21.37	0.4810
27.22	0.4564
33.38	0.4323
39.96	0.4090

A = 6.6577
B = 134.32
n = 1.4329

CH_3NO (20)

Formamide

0	7.552
76.5	1.254
(68)	
25	3.359
40	2.379
(27)	
105	0.768
120	0.659

A = 874
B = 60.78
n = 2.2780

CH_3NO_2 (18)

Nitromethane

25	0.619
(74)	
0	0.843
25	0.631
40	0.526
55	0.450
70	0.392
85	0.342

CH_4O

Methyl alcohol
v. Vol. V, p. 11

CH_5N (38)

Methylamine

0	0.2364

C_2Cl_4 (91)

Tetrachloroethylene

0	1.133
11.24	0.986
22.30	0.869
32.34	0.784
42.78	0.707
52.68	0.645
64.14	0.585
74.67	0.536
85.75	0.491
95.60	0.455
106.03	0.422
117.09	0.390

C_2Cl_4.—(*Cont'd*)

A = 30.656
B = 126.17
n = 1.6325

t, °C	100η
(13)	
25	0.841
50	0.656
75	0.534

C_2Cl_6

Hexachloroethane

(79)	
25	2.26

C_2HBr_3O (33)

Bromal

25	5.31
40	3.725
50	3.026
60	2.501
70	2.081
85	1.607
100	1.264

C_2HCl_3 (44)

Trichloroethylene

25	0.550
50	0.446
75	0.371

C_2HCl_3O (33)

Chloral

25	0.1263
40	1.01
50	0.87
70	0.68
85	0.56

$C_2HCl_3O_2$ (49)

Trichloroacetic acid

60	3.97
70	3.15

C_2HCl_5 (79)

Pentachloroethane

0	3.73
25	2.26
(44)	
25	2.176
50	1.480
75	1.061

$C_2H_2Br_2$ (91)

1, 2-Acetylene dibromide

0.86	1.217
10.95	1.070
19.93	0.960
30.14	0.859
39.49	0.782
47.80	0.722
57.96	0.659
67.19	0.610
76.72	0.565
85.95	0.525
97.10	0.483
105.72	0.454

A = 14.868
B = 112.29
n = 1.5032

$C_2H_2Cl_2$ (44)

cis-1, 2-Acetylene dichloride

t, °C	100η
25	0.391

$C_2H_2Cl_2$ (44)

trans-1, 2-Acetylene dichloride

25	0.4564
50	0.3685

$C_2H_2Cl_4$ (17*)

1, 1, 2, 2-Tetrachloroethane

0	2.656
10	2.147
15	1.952
25	1.637
35	1.389
50	1.132
(44)	
75	0.8185
(20)	
80	0.763

* $1/\eta_t = 0.13796 \times [1 + 0.019171t + 0.00000925t^2] \times (273.1 + t)$.

$C_2H_3Br_3O_2$ (33)

Bromal hydrate

40	46.14
50	20.69
60	10.9
70	6.349
85	5.166
100	2.00

C_2H_3N (78)

Acetonitrile

25	0.36

$C_2H_4Br_2$

Ethylene bromide

(91)	
9.49	2.053
20.63	1.698
31.21	1.445
41.64	1.252
51.81	1.099
62.87	0.967
73.48	0.862
85.97	0.762
95.81	0.694
105.71	0.634
117.01	0.577
126.71	0.532

A = 30.535
B = 80.802
n = 1.6222

$C_2H_4Cl_2$ (91)

1,1-Dichloroethane

7.06	0.5686
11.24	0.5413
15.34	0.5156
19.31	0.4934
23.22	0.4736
27.85	0.4506
31.55	0.4337

$C_3H_4Cl_2$.—(*Cont'd*)

t, °C	100η
35.61	0.4160
40.18	0.3976
43.74	0.3836
47.95	0.3695
54.54	0.3476

A = 22.247
B = 132.02
n = 1.6762

$C_2H_4Cl_2$ (91)

Ethylene chloride

0.31	1.1211
7.23	1.0021
14.73	0.8961
21.84	0.8129
28.78	0.7417
36.88	0.6695
43.89	0.6166
51.74	0.5668
58.53	0.5239
65.53	0.4912
72.95	0.4558
81.07	0.4217

A = 24.256
B = 100.67
n = 1.6641

C_2H_4O (91)

Acetaldehyde

0.33	0.2663
5.35	0.2538
9.56	0.2442
13.92	0.2345
19.17	0.2234

A = 15652.2
B = 286.11
n = 2.7550

C_2H_4O (64)

Ethylene oxide

−49.8	0.5772
−45.7	0.5387
−38.2	0.4883
−32.6	0.4505
−21	0.3937
−13.6	0.3637
0	0.3202
+ 9.3	0.2927

$C_2H_4O_2$ (91)

Acetic acid

30.86	1.025
39.88	0.903
48.47	0.806
57.46	0.721
68.10	0.638
76.66	0.580
84.53	0.534
93.97	0.484
102.89	0.445
112.57	0.406

A = 267.814
B = 112.207
n = 2.0492

$C_2H_4O_2$.—(*Cont'd*)

t, °C	100η
(13*)	
25	1.148
35	0.991
45	0.865
55	0.760
65	0.676
75	0.607
85	0.546
95	0.489
(39)	
20	1.234
(49)	
25	1.121

* $1/\eta_t = 0.2072 [1 + 0.01597t + 0.0000178t^2] \times (273.1 + t)$.

$C_2H_4O_2$ (92)

Methyl formate

0.58	0.4263
6.39	0.3999
10.88	0.3809
15.63	0.3626
20.15	0.3467
25.52	0.3298
29.25	0.3190

A = 0.144673
B = 68.234
n = 0.8325

(39)	
20	0.367

C_2H_5Br (91)

Ethyl bromide

0.34	0.4759
5.18	0.4525
9.67	0.4327
15.46	0.4087
20.54	0.3903
25.28	0.3734
30.03	0.3581
36.15	0.3394

A = 6.8898
B = 138.65
n = 1.4749

(46)	
19.2	0.3973
19.9	0.3968
46	0.3037
77	0.2336

C_2H_5I (91)

Ethyl iodide

0.28	0.7167
7.70	0.6605
13.18	0.6235
20.80	0.5782
26.09	0.5496
32.98	0.5151
38.74	0.4891
45.24	0.4621
51.39	0.4387
57.51	0.4168
63.72	0.3966
69.38	0.3792

A = 50.810
B = 157.42
n = 1.7520

C_2H_5I.—(*Cont'd*)

t, °C	100η
(79)	
0	0.725

C_2H_5NO (27)
Acetamide

105	1.32
120	1.06

$C_2H_5NO_2$ (81)
Methyl carbamate

55.6	2.28
74.6	1.37
82.2	1.24
99	0.85

C_2H_6O
Ethyl alcohol
v. Vol. V, p. 11

$C_2H_6O_2$ (23)
Glycol

25	17.4

$C_2H_6O_4S$ (20)
Dimethyl sulfate

0	2.732
76.5	0.802

C_2H_6S (91)
Methyl sulfide

0.27	0.3529
5.56	0.3351
10.05	0.3209
14.75	0.3075
20.19	0.2927
26.14	0.2776
31.35	0.2655
35.81	0.2559

A = 21.768
B = 170.34
n = 1.6981

C_2H_6S (22)
Ethylmercaptan

25	0.210

C_2H_7N (34)
Dimethylamine

−33.5	0.3208

C_2H_7N (34)
Ethylamine

−33.5	0.4368

$C_2H_8N_2$ (26)
Ethylenediamine

25	1.54

$C_3H_2N_2$ (103)
Malonic nitrile

32.68	2.85
50	2.15

C_3H_5Br (91)
3-Bromopropylene

0.30	0.6168
6.64	0.5730
12.42	0.5372
18.34	0.5046
24.73	0.4727
30.84	0.4449
37.22	0.4198
42.84	0.3988
47.86	0.3805
54.55	0.3587

C_3H_5Br.—(*Cont'd*)

t, °C	100η
61.15	0.3402
68.67	0.3193

A = 30.360
B = 145.03
n = 1.7075

C_3H_5Cl (91)
3-Chloropropylene

0.53	0.4035
5.98	0.3800
11.19	0.3598
16.66	0.3408
21.93	0.3230
28.32	0.3039
33.97	0.2885
38.37	0.2774
42.10	0.2681

A = 27.705
B = 157.08
n = 1.7549

C_3H_5ClO (18)
α-Epichlorohydrin

25	1.03

C_3H_5I (91)
3-Iodopropylene

0.33	0.926
9.33	0.825
16.77	0.754
26.12	0.679
35.77	0.614
44.18	0.565
55.16	0.510
63.44	0.476
71.14	0.443
81.29	0.410
91.86	0.375
98.45	0.358

A = 28.411
B = 126.05
n = 1.6592

C_3H_5N (96)
Propionitrile

0	0.541
25	0.413

C_3H_5NS (96)
Ethyl thiocyanate

0	1.105
25	0.779

$C_3H_6Br_2$ (91)
1,2-Dibromopropane

0.36	2.285
12.91	1.816
25.27	1.494
38.02	1.247
50.08	1.072
63.19	0.918
76.46	0.797
89.13	0.704
101.18	0.628
113.71	0.565
127.97	0.501
136.67	0.468

A = 48.803
B = 88.757
n = 1.7075

$C_3H_6Br_2$ (26)
1, 3-Dibromopropane

t, °C	100η
25	1.797

$C_3H_6Cl_2$ (26)
1, 3-Dichloropropane

25	0.873

C_3H_6O (91)
Allyl alcohol

7.41	1.810
15.31	1.508
22.81	1.283
30.50	1.096
38.05	0.946
46.36	0.811
54.10	0.708
60.77	0.633
68.86	0.557
76.81	0.492
84.50	0.440
92.26	0.394
95.24	0.379

A = 10 748.4
B = 109.42
n = 2.7925

(23)

25	1.237

C_3H_6O (18)
Propionaldehyde

25	0.435

(96)

0	0.467
25	0.344

C_3H_6O (91)
Acetone

7.86	0.3638
11.72	0.3495
15.24	0.3376
19.02	0.3258
23.01	0.3131
27.22	0.3007
32.43	0.2863
36	0.2772
40.04	0.2675
44.12	0.2584
47.62	0.2503
52.20	0.2405
53.86	0.2377

A = 572.63
B = 209.08
n = 2.2244

(21)

10	0.362
20	0.331

(6)

0	0.399
15	0.345
25	0.316

(14)

0	0.397
10	0.361
20	0.325
30	0.296

C_3H_6O.—(*Cont'd*)

t, °C	100η
40	0.271
50	0.249

(1)

0	0.389
−10.6	0.451
−20.4	0.516
−30.3	0.613
−40	0.713
−49.9	0.818
−59.7	0.981
−69.7	1.200
−79.7	1.505
−89.7	2.051

$C_3H_6O_2$ (91)
Propionic acid

4.70	1.404
16.87	1.151
28.21	0.979
40.04	0.839
52.03	0.729
63.63	0.642
76.70	0.562
89.56	0.496
101.01	0.448
112.98	0.403
123.67	0.368
137.05	0.329

A = 105.746
B = 109.53
n = 1.8840

(39)

20	1.109

$C_3H_6O_2$ (92)
Ethyl formate

0.46	0.5024
6.57	0.4656
11.52	0.4409
16.58	0.4171
22.59	0.3910
27.90	0.3699
33.25	0.3501
38.09	0.3344
43.36	0.3178
48.61	0.3030
52.03	0.2942

A = 22.2406
B = 139.932
n = 1.7006

(39)

20	0.4132

(58)

25	0.389
30	0.375
40	0.345
50	0.311

(31)

25	0.379

$C_3H_6O_2$ (92)
Methyl acetate

0.34	0.4762
6.31	0.4436
11.41	0.4186
16.70	0.3948
22.74	0.3706

$C_3H_6O_2$.—(*Cont'd*)

t, °C	100η
28.38	0.3492
33.85	0.3304
40.45	0.3100
46.06	0.2942
50.34	0.2828
54.33	0.2727

A = 57.4012
B = 154.499
n = 1.8636

(39)

20	0.3831

$C_3H_6O_3$ (23)
Lactic acid

25	40.5

C_3H_7Br (91)
n-Propyl bromide

0.45	0.6414
7.86	0.5884
13.66	0.5523
19.17	0.5209
25.44	0.4903
31.88	0.4588
38.60	0.4300
45.64	0.4032
51.01	0.3844
57.37	0.3633
61.98	0.3495
67.86	0.3328

A = 65.713
B = 155.75
n = 1.8282

C_3H_7Br (91)
Isopropyl bromide

0.33	0.6021
5.12	0.5688
10.14	0.5371
15.30	0.5068
20.28	0.4803
25.46	0.4551
29.94	0.4343
35.90	0.4095
41.17	0.3894
46.36	0.3704
50.91	0.3555
56.76	0.3371

A = 188.08
B = 169.03
n = 2.0166

C_3H_7Cl (91)
n-Propyl chloride

0.45	0.4327
5.24	0.4104
10.06	0.3894
14.65	0.3709
20.71	0.3495
25.76	0.3344
30.38	0.3178
35.38	0.3038
40.82	0.2887
44.68	0.2784

A = 662.52
B = 203.36
n = 2.2453

C_3H_7Cl (91)
Isopropyl chloride

t, °C	100η
0.27	0.4000
6.68	0.3714
11.02	0.3540
16.47	0.3341
22.50	0.3137
28.22	0.2962
33.02	0.2829

A = 9.2541
B = 133.60
n = 1.5819

C_3H_7I (91)
n-Propyl iodide

0.30	0.934
10.98	0.817
20.81	0.730
28.31	0.673
38.83	0.605
46.17	0.564
55.59	0.516
65.46	0.474
74.38	0.439
83.88	0.406
90.78	0.384
98.89	0.362

A = 50.893
B = 136.84
n = 1.7483

C_3H_7I (91)
Isopropyl iodide

0.30	0.875
9.18	0.782
15.92	0.722
23.43	0.664
32.69	0.601
40.67	0.555
49.43	0.509
57.01	0.475
65.44	0.440
71.49	0.418
80.45	0.388
88.72	0.361

A = 129.85
B = 150.03
n = 1.9161

C_3H_7N (72)
Allylamine

25	0.3745

C_3H_7NO (27)
Propionamide

105	1.27
120	1.03

$C_3H_7NO_2$ (85)
Urethane

60	2.357
70	1.805
80	1.456

(27)

105	0.916
120	0.715

C_3H_8O (91)
n-Propyl alcohol

t, °C	100η
7.35	3.145
15.06	2.555
22.86	2.101
30.83	1.732
31.02	1.724
38.79	1.440
46.47	1.218
54.33	1.030
61.74	0.888
69.04	0.771
76.75	0.666
84.82	0.576
93.10	0.499
95.59	0.477

A = 8 801 350
B = 135.75
n = 3.9188

(39)

10	2.877
20	2.230
30	1.756
40	1.389
50	1.125

(73)

0	4.137
13.4	2.868

C_3H_8O (91)
Isopropyl alcohol

0.36	4.5018
7.21	3.5568
14.41	2.8157
22.22	2.2204
30.55	1.7275
37.92	1.4053

A = 2 175 320 000
B = 141.72
n = 4.9635

(91)

45.15	1.1604
51.97	0.9770
59.39	0.8157
66.60	0.6923
72.02	0.6141
78.09	0.5407

A = 192 398
B = 86.259
n = 3.4079

(39)

10	3.319
20	2.431
30	1.810
40	1.375
50	1.063

(29)

20	2.19
25	1.95
30	1.74

$C_3H_8O_2$ (39)
1, 2-Propyleneglycol

20	44.80

C_3H_9N (72)
n-Propylamine

t, °C	100η
25	0.353

C_3H_9N (34)
Trimethylamine

−33.5	0.3208

$C_3H_{10}N_2$ (26)
Trimethylenediamine

25	1.81

C_4H_4S (91)
Thiophene

0.24	0.8676
8.39	0.7692
16.61	0.6876
22.50	0.6384
31.12	0.5754
37.83	0.5328
44.94	0.4934
53.08	0.4540
61.66	0.4170
68.60	0.3907
75.06	0.3682
82.53	0.3447

A = 15.677
B = 105.87
n = 1.6078

C_4H_5NS (59)
Allyl thiocyanate

25	0.673
50	0.541
80	0.427

(57.5)

100	0.316
125	0.263

$C_4H_6O_2$ (88)
Trimethylenecarboxylic acid

25	2.98

$C_4H_6O_3$ (91)
Acetic anhydride

0.18	1.238
12.52	1.007
24.10	0.852
35.40	0.734
48.15	0.630
60.39	0.551
71.04	0.494
84.42	0.434
95.09	0.394
108.92	0.351
120.23	0.320
133.39	0.289

A = 27.713
B = 97.10
n = 1.6851

(39)

20	0.946

(20)

10	1.058
15	0.979
76.5	0.462

$C_4H_8Br_2$ (91)
1, 2-Dibromo-2-methylpropane

t, °C	100η
0.39	3.290
13.67	2.456
26.94	1.916
40.80	1.528
53.18	1.274
66.90	1.065
80.60	0.903
93.63	0.781
107.15	0.680
121.74	0.593
133.75	0.532
142.44	0.494

A = 79.485
B = 75.60
n = 1.7988

C_4H_8O (91)
Methyl ethyl ketone

0.32	0.5361
7.04	0.4923
14.10	0.4522
21.31	0.4170
28.36	0.3861
35.42	0.3586
42.49	0.3342
48.72	0.3149
55.92	0.2944
63.74	0.2750
70.26	0.2595
76.25	0.2465

A = 36.972
B = 139.33
n = 1.7895

(65)

25	0.497

(39)

20	0.442

$C_4H_8O_2$ (91)
n-Butyric acid

3.21	2.128
18.02	1.591
31.83	1.263
44.49	1.049
59.39	0.860
73.36	0.727
86.55	0.628
101.55	0.537
115.24	0.470
130.26	0.408
144.97	0.358
155.76	0.327

A = 195.765
B = 94.462
n = 1.99205

(39)

10	1.920
20	1.599
30	1.341
40	1.160
50	1.004

$C_4H_8O_2$ (91)
Isobutyric acid

t, °C	100η
3.69	1.761
17	1.383
29.33	1.137
42.53	0.945
54.54	0.811
70.49	0.674
88.06	0.560
98.94	0.499
109.78	0.450
120.97	0.407
134.50	0.361
147.47	0.323

A = 212.41
B = 104.63
n = 2.00595

$C_4H_8O_2$ (92)
Ethyl acetate

0.25	0.5763
8.90	0.5144
14.46	0.4795
21.38	0.4418
28.12	0.4096
36.54	0.3738
44.12	0.3455
51.15	0.3224
60.16	0.2960
68.43	0.2741
74.60	0.2594

A = 45.322
B = 135.423
n = 1.8268

(39)

20	0.4521

(58)

25	0.441
50	0.345
70	0.283

(101)

0	0.588

(46, 47)

20.9	4.533
46.2	3.375
77.7	2.515
99.6	2.090

(51)

25	0.4239

(49)

25	0.4236

$C_4H_8O_2$ (92)
Methyl propionate

0.38	0.5788
9.73	0.5142
16.79	0.4725
23.46	0.4368
29.61	0.4098
38.66	0.3746
45.59	0.3477
52.65	0.3254
60.37	0.3028
68.49	0.2812

A = 74.898
B = 146.621
n = 1.89725

$C_4H_8O_2$.—*(Cont'd)*

t, °C	100η
(39)	
20	0.461

$C_4H_8O_2$ (92)
n-Propyl formate

0.35	0.6647
7.33	0.6041
15.54	0.5457
23.16	0.4975
30.77	0.4558
38.53	0.4184
45.73	0.3875
54.14	0.3565
61.56	0.3315
67.13	0.3136
74.98	0.2928
77.55	0.2861

A = 35.3453
B = 139.283
n = 1.9154

(39)

20	0.5134

$C_4H_8O_2$ (39)
Isopropyl formate

20	0.5649

C_4H_9Br (91)
Isobutyl bromide

0.34	0.820
7.40	0.745
16.08	0.669
23.71	0.611
32.17	0.556
40.34	0.510
48.39	0.470
56.14	0.435
64.17	0.404
72.57	0.373
80.18	0.348
87.93	0.323

A = 472.23
B = 161.62
n = 2.1547

C_4H_9Cl (91)
Isobutyl chloride

0.35	0.5816
5.97	0.5401
11.95	0.5015
18.69	0.4637
23.47	0.4386
29.46	0.4102
37.32	0.3768
42.43	0.3575
48.71	0.3359
53.74	0.3197
60.26	0.3007
65.30	0.2877

A = 61.940
B = 141.87
n = 1.8706

C_4H_9I (91)
Isobutyl iodide

0.45	1.154
11.23	0.978
22.44	0.844

C_4H_9I.—*(Cont'd)*

t, °C	100η
33.84	0.739
44.56	0.658
54.65	0.593
65.11	0.536
77.33	0.480
86.83	0.442
97.84	0.403
109.20	0.368
116.07	0.349

A = 27.652
B = 108.86
n = 1.6577

C_4H_9N (88)
Tetrahydropyrrole

25	0.697

C_4H_{10} (54)
n-Butane

−23.6	0.265
0	0.207
18.5	0.176
34.5	0.153

$C_4H_{10}O$ (91)
n-Butyl alcohol

0.27	5.154
10.69	3.796
21.83	2.801
31.73	2.172
42.91	1.661

A = 65 187 500
B = 139.05
n = 4.2452

52.17	1.344
61.99	1.090
72.24	0.8860
83.13	0.7183
94.88	0.5817
102.96	0.5096
114.11	0.4259

A = 117 255
B = 91.997
n = 3.2150

$C_4H_{10}O$ (91)
Isobutyl alcohol

0.45	7.9111
9.90	5.5735
19.01	3.9779
27.77	3.0658
38.16	2.2392

A = 1 486 370
B = 92.248
n = 3.6978

47.44	1.7217
56.48	1.3571
56.59	1.3502
65.95	1.0697
74.61	0.8748

A = 1 112 440
B = 86.751
n = 3.6708

83.95	0.7173
93.85	0.5864
105.07	0.4753

$C_4H_{10}O$.—(*Cont'd*)

A = 29 790.3
B = 63.14
n = 3.0537

(67)

t, °C	100η
18.8	3.93

(35)

25	3.38_2

$C_4H_{10}O$ (91)
tert.-Butyl alcohol

22.41	5.887
32.08	3.004
37.22	2.367
42.41	1.909
47.82	1.550

A = 2.05152
B = −7.803
n = 1.3242

52.99	1.296
57.94	1.097
62.09	0.9678
68.35	0.8102
73.47	0.7057
77.05	0.6447

A = 46.3090
B = 5.077
n = 2.0143

$C_4H_{10}O$
Ethyl ether
v. Vol. V, p. 11

$C_4H_{10}O$ (91)
Methyl propyl ether

0.30	0.3064
5.14	0.2914
10.47	0.2759
15.17	0.2630
20.10	0.2513
25.73	0.2385
29.48	0.2300
35.15	0.2187

A = 8.4251
B = 146.862
n = 1.5863

$C_4H_{10}S$ (91)
Ethyl sulfide

0.21	0.5575
8.32	0.5064
15.85	0.4652
24.64	0.4233
32.63	0.3901
40.19	0.3623
47.75	0.3374
56.49	0.3118
63.50	0.2933
71.25	0.2749
80.31	0.2555
87.99	0.2406

A = 49.886
B = 149.15
n = 1.8175

$C_4H_{11}N$ (72)
n-Butylamine

25	0.68_1

$C_4H_{11}N$ (72)
Isobutylamine

t, °C	100η
25	0.55_3

$C_4H_{11}N$ (59)
Diethylamine

25	0.34_6
35	0.27_9
25 (72)	0.36_7

(34)

-33.5	0.8236

C_5H_5N (14)
Pyridine

0	1.328
10	1.112
20	0.945
30	0.824
40	0.717
60	0.580
80	0.489
110	0.386

(77)

25	0.889

(27)

25	0.884

(41)

0	1.33
25.08	0.888

C_5H_8 (91)
Isoprene

0.35	0.2589
5.62	0.2459
10.27	0.2358
15.33	0.2249
20.41	0.2147
25.25	0.2060
28.94	0.1996
32.02	0.1944
29.93	0.1985

A = 3.3891
B = 144.01
n = 1.4433

C_5H_8O (88)
Cyclopentanone

25	1.07

C_5H_8O (48)
Ethyl propargyl ether

25	0.52_9

$C_5H_8O_2$ (88)
Cyclobutanecarboxylic acid

25	2.45

$C_5H_8O_3$ (39)
Methyl acetoacetate

20	1.702

C_5H_{10} (16)
Cyclopentane

0	0.572
15	0.477
20	0.456
25	0.427
30	0.406

C_5H_{10} (91)
2-Methyl-2-butene

t, °C	100η
0.20	0.2529
5.46	0.2406
10.21	0.2306
15.82	0.2192
20.03	0.2114
25.75	0.2015
30.69	0.1931
32.59	0.1903

A = 28.916
B = 187.24
n = 1.7855

$C_5H_{10}Br_2$ (26)
1, 5-Dibromopentane

25	0.305

$C_5H_{10}Cl_2$ (26)
Dichloropentane

25	1.60

$C_5H_{10}O$ (91)
Diethyl ketone

0.46	0.5914
9.10	0.5302
18.70	0.4748
27.07	0.4328
36.21	0.3939
44.70	0.3623
53.44	0.3339
62.43	0.3079
72.20	0.2834
81.47	0.2623
90.97	0.2426
98.82	0.2279

A = 64.487
B = 146.67
n = 1.8626

(39)

20	0.4799

(88)

25	0.442

$C_5H_{10}O$ (91)
Methyl propyl ketone

0.38	0.6404
9.40	0.5692
18.30	0.5109
27.77	0.4592
35.43	0.4234
45.29	0.3831
53.94	0.3525
62.24	0.3262
72.74	0.2980
80.64	0.2787
90.06	0.2574
98.77	0.2400

A = 51.543
B = 137.75
n = 1.8248

(88)

25	0.473

$C_5H_{10}O_2$ (39)
Methylethylacetic acid

t, °C	100η
20	2.055

$C_5H_{10}O_2$ (24)
n-Valeric acid

16.5	2.41
20	2.30
25	2.05
50	1.31_5
70	0.98_6
90	0.75_3

(31)

50	1.25
70	0.97_9

(39)

20	2.233

$C_5H_{10}O_2$ (93)
Isovaleric acid

20	2.411

$C_5H_{10}O_2$ (39)
n-Butyl formate

20	0.5627

$C_5H_{10}O_2$ (39)
Isobutyl formate

20	0.6650

(66)

20	0.644

$C_5H_{10}O_2$ (92)
Ethyl propionate

0.39	0.6890
10.09	0.6037
20.08	0.5310
29.74	0.4735
39.88	0.4230
49.68	0.3817
59.14	0.3477
69.24	0.3155
72.12	0.3073
80.14	0.2854
89.69	0.2627

A = 72.981
B = 133.905
n = 1.8914

(39)

20	0.5367

(66)

20	0.549

$C_5H_{10}O_2$ (92)
Methyl n-butyrate

0.32	0.7551
10.45	0.6527
20.38	0.5727
30.64	0.5049
40.58	0.4503
50.30	0.4058
60.20	0.3667
71.50	0.3295
79.45	0.3057
90.63	0.2767
98.28	0.2592

A = 53.0991
B = 123.745
n = 1.8375

$C_5H_{10}O_2$ (92)
Methyl isobutyrate

t, °C	100η
0.28	0.6687
9.40	0.5914
18.11	0.5299
28.98	0.4660
35.81	0.4317
44.66	0.3932
52.55	0.3631
62.72	0.3289
76.22	0.3036
79.77	0.2813
88.84	0.2588

A = 98.0935
B = 139.956
n = 1.9405

(39)

20	0.5170

$C_5H_{10}O_2$ (92)
n-Propyl acetate

0.38	0.7652
9.78	0.6659
20.59	0.5762
30.13	0.5108
39.75	0.4563
50.04	0.4079
61.36	0.3624
69.90	0.3331
80	0.3028
89.50	0.2775
96.90	0.2602

A = 73.6005
B = 125.269
n = 1.8972

(6)

25	0.557

(66)

20	0.592

(39)

20	0.5959

$C_5H_{10}O_2$ (39)
Isopropyl acetate

20	0.5247

$C_5H_{11}N$ (88)
Piperidine

25	1.37

(59)

25	1.36
50	0.84_5
80	0.73_8

C_5H_{12}* (91)
Isopentane

A = 391.101
B = 208.6
n = 2.2186

* Data given for isopentane prepared from English, Scotch, and Irish amyl alcohols.

C_5H_{12} (91)
n-Pentane

t, °C	100η
0.74	0.2805
7.47	0.2620
13.16	0.2481
18.91	0.2351
26.30	0.2192
30.41	0.2110
32.66	0.2070

A = 19.459
B = 165.59
n = 1.7295

$C_5H_{12}O$ (91)
d-Amyl alcohol

0.40	10.9672
11.63	6.9581
23.30	4.5372
34.75	3.0788

A = 66 652 700
B = 101.51
n = 4.3736
$0° \le t \le 35°$

47.40	2.0880
56.94	1.5956
67.52	1.2183

A = 97 413.3
B = 64.67
n = 3.2542
$35° \le t \le 73°$

79.25*	0.9254
91.88*	0.7075
100.03*	0.6033
112.78*	0.4819
124.36*	0.4008

A = 71.8436
B = 7.838
n = 2.0050

* $273.1 + t = \frac{0.26970}{\eta}$
$335.66 + \frac{1425.7}{1/\eta} + \frac{7618.7}{1/\eta^2}$

$C_5H_{12}O$ (91)
Isoamyl alcohol

0.24	8.4610
11.91	5.6249
23.83	3.8633
34.25	2.8303

A = 77 360 200
B = 117.79
n = 4.3249
$0° \le t \le 40°$

47.66	1.9654
58.74	1.4847
71.05	1.1210

A = 211 442
B = 79.872
n = 3.3395
$40° \le t \le 80°$

81.87	0.8888
94.94	0.6872
104.58	0.5794
117.60	0.4654
128.10	0.3974

$C_5H_{12}O$.—*(Cont'd)*

A = 1156.78
B = 37.682
n = 2.4618
$80° \leq t \leq 128°$

$C_5H_{12}O$ (91)
tert.-Amyl alcohol

t, °C	100η
0.49	13.7969
9.31	8.2034
18.48	4.9978
27.24	3.3643

A = 35 091
B = 47.922
n = 3.2081
$0° \leq t \leq 27°$

36.42	2.3322
45.05	1.7135
53.18	1.3199
62.95	0.9943

A = 3255.20
B = 37.007
n = 2.7578
$27° \leq t \leq 63°$

71.91	0.7931
81.06	0.6400
89.94	0.5301
95.70	0.4718
96.70	0.4643

A = 2159.86
B = 38.340
n = 2.6611
$60° \leq t \leq 95°$

(16)

25	3.697
40	1.975
50	1.401
70	0.798
85	0.573

$C_5H_{12}O$ (29)
sec.-Amyl alcohol

25	3.103

$C_5H_{12}O$ (29)
Methylisopropyl carbinol

25	3.525

$C_5H_{12}O$ (92)
Ethyl propyl ether

0.35	0.3952
5.65	0.3714
10.65	0.3510
15.66	0.3324
20.32	0.3165
25.34	0.3006
30.08	0.2864
35.08	0.2727
39.98	0.2598
45.62	0.2466
50.30	0.2363
55	0.2264
60.18	0.2159

A = 284.675
B = 183.355
n = 2.1454

$C_5H_{12}O$ (92)
Methyl isobutyl ether

t, °C	100η
0.36	0.3797
6.92	0.3526
14.51	0.3246
21.35	0.3022
28.89	0.2800
35.98	0.2620
42.55	0.2458
49.75	0.2305
55.22	0.2192

A = 122.591
B = 174.318
n = 2.0109

$C_5H_{13}N$ (72)
Isoamylamine

25	0.7235

$C_5H_{13}N$ (88)
Ethyl-*n*-propylamine

25	0.903

$C_5H_{14}N_2$ (26)
Pentamethylendiamine

25	2.36

$C_6H_3N_3O_6$ (57)
1, 3, 5-Trinitrobenzene

152	1.57

$C_6H_4N_2O_4$ (55)
m-Dinitrobenzene

90	2.53

C_6H_5Br (69)
Bromobenzene

0.1	1.573
5.9	1.445
10.1	1.332
18.2	1.171
28.3	1.023
43.6	0.842
61.4	0.694
71.2	0.626
80.7	0.579
91	0.526
102.2	0.485
111.7	0.445
121.7	0.417
132.3	0.373
142.3	0.351

(79)

0	1.50

C_6H_5Cl (69)
Chlorobenzene

0	1.053
4.7	0.988
9.7	0.917
15.9	0.848
17.6	0.827
20.1	0.800
25.1	0.751
30.2	0.704
40.2	0.629

C_6H_5Cl.—*(Cont'd)*

t, °C	100η
49.9	0.570
60	0.513
72.1	0.460
80.4	0.428
88.1	0.393
96.2	0.369
107.8	0.344
119.6	0.307

(26)

25	0.76

(14)

20	0.77

C_6H_5ClO (14.5)
o-Chlorophenol

0	10.7
10	6.39
20	4.21
30	3.08
40	2.32
60	1.51
80	1.07
110	0.76
150	0.54

(86)

45	2.291

(90)

25	4.11
50	2.0

C_6H_5ClO (86)
m-Chlorophenol

45	4.82

(90)

25	11.5
50	4.0

C_6H_5ClO (86)
p-Chlorophenol

45	6.15

(90)

50	5.0

C_6H_5F (69)
Fluorobenzene

9.3	0.647
15.9	0.615
19.9	0.577
29.1	0.514
33.2	0.495
38.1	0.468
44	0.438
50.2	0.412
60.5	0.370
71.9	0.334
80.9	0.305

C_6H_5I (69)
Iodobenzene

4.6	2.207
17.4	1.780
27.5	1.504
36.8	1.316
48.1	1.135
58.1	1.005
68.2	0.902
80.6	0.792
98	0.673

C_6H_5I.—*(Cont'd)*

t, °C	100η
107.5	0.623
117.7	0.549
126.9	0.529
137.6	0.487
148.8	0.448

$C_6H_5NO_2$ (9); *cf.* (14, 18, 19, 20, 21, 81, 89)
Nitrobenzene

0.3	3.083
10	2.509
20	2.013
30	1.682
40	1.438
50	1.251
60	1.094
70	0.970
90	0.779
100.5	0.704

$C_6H_5NO_3$ (14)
o-Nitrophenol

40	2.75
60	1.82
80	1.35

(86)

45	2.388

C_6H_6
Benzene
v. Vol. V, p. 12

C_6H_6ClN (87)
o-Chloroaniline

55	1.65

C_6H_6ClN (87)
m-Chloroaniline

55	1.76

(78)

25	3.50

C_6H_6ClN (87)
p-Chloroaniline

55	1.96

C_6H_6O (80)
Phenol

18.30	12.744
20.38	11.384
25.03	8.976
29.26	7.371
35.25	5.779
38.04	5.151
39.51	4.876
40.20	4.771
49.84	3.449
55.52	2.903
60.46	2.531
66.45	2.163
70.30	1.973

(12*)

35	6.024
40	4.803
45	4.000
50	3.419
55	2.938
60	2.562

C_6H_6O.—*(Cont'd)*

t, °C	100η
65	2.249
70	1.997
75	1.779
80	1.596
85	1.439
90	1.306

$$*\eta t = \frac{1}{(0.001511t + 0.00001075t^2 - 0.01219) \times (273.1 + t)}.$$

C_6H_7N (36*)
Aniline

−5.50	13.86
−0.06	10.25
0	10.24
+2.50	9.15
10.35	6.44
15.35	5.20
16.32	5.015
17.38	4.845
31.76	2.977
49.01	1.84
61.27	1.488
80.33	1.099
100.39	0.829
119.87	0.660
120	0.653

(9)

0.5	10.050
10	6.491
15	5.379
20	4.429
25	3.781
30	3.221
35	2.826
45	2.158
60	1.553
80	1.094
98	0.838

$$*\log(100\eta) = -1.1485 \times \left(\frac{t - 85.26}{t + 97.1}\right).$$

C_6H_7N (32)
α-Picoline

25	0.795

C_6H_7N (32)
β-Picoline

25	0.876

$C_6H_8N_2$ (90)
Phenylhydrazine

50	4.58

C_6H_{10} (91)
Diisopropenyl

0.37	0.3374
5.95	0.3169
10.78	0.3010
15.46	0.2866
20.76	0.2719
25.46	0.2599
30.71	0.2474
36.06	0.2355
41.99	0.2229

C_6H_{10}.—*(Cont'd)*

t, °C	100η
46.76	0.2137
51.54	0.2047
56.20	0.1966

A = 72.193
B = 173.01
n = 1.9340

(39)

20	0.2733

$C_6H_{10}O$ (42.5)
Cyclohexanone

17.3	2.30
39.1	1.55
65.9	1.01

(88)

25	2.8

$C_6H_{10}O$ (25)
Mesityl oxide

25	0.879

$C_6H_{10}O_2$ (88)
Ethyl cyclopropanecarboxylate

25	0.98

$C_6H_{10}O_3$ (91)
Propionic anhydride

0.47	1.592
14.70	1.220
29.97	0.960
44.86	0.780
59.52	0.651
74.87	0.549
94.87	0.450
104.52	0.412
119.57	0.361
134.65	0.319
148.66	0.287
164.56	0.254

A = 31.312
B = 85.011
n = 1.7049

$C_6H_{10}O_3$ (39)
Ethyl acetoacetate

20	1.712

(89)

25	1.53* 1.54†

* Freshly distilled.
† After standing 90 min.

$C_6H_{10}O_4$ (26)
Diethyl oxalate

25	1.76

C_6H_{12} (16)
Cyclohexane

15	1.043
20	0.960
30	0.797

(19)

22	0.93

t, °C	100η
C_6H_{12} (16) Methylcyclopentane	
0	0.665
15	0.545
20	0.521
25	0.484
30	0.456
$C_6H_{12}O$ (42.5) Cyclohexanol	
39.1	20.3
65.9	5.8
90	2.45
$C_6H_{12}O$ (39) Methyl *n*-butyl ketone	
20	0.6261
(88)	
25	0.58_4
$C_6H_{12}O$ (39) Methyl isobutyl ketone	
20	0.5799
$C_6H_{12}O_2$ (39) Caproic acid	
20	3.198
(24)	
16.1	3.56
20	3.23
25	2.84
40	2.12
50	1.75
70	1.29
90	0.98
$C_6H_{12}O_2$ (39) Diethylacetic acid	
20	3.159
$C_6H_{12}O_2$ (39) Methylpropylacetic acid	
20	2.867
$C_6H_{12}O_2$ (66) Isoamyl formate	
20	0.794
$C_6H_{12}O_2$ (39) Isobutyl acetate	
20	0.7034
(46)	
19.9	0.724
78.1	0.366
99.4	0.287
$C_6H_{12}O_2$ (39) Ethyl *n*-butyrate	
20	0.6668
(66)	
20	0.668
(58)	
25	0.62_8
50	0.46_6
70	0.38_1

t, °C	100η
$C_6H_{12}O_2$ (39) Ethyl isobutyrate	
20	0.588
(88)	
25	0.55_7
$C_6H_{12}O_2$ (39) Methyl *n*-valerate	
20	0.7119
$C_6H_{12}O_2$ (39) *n*-Propyl propionate	
20	0.6722
(66)	
20	0.678
$C_6H_{12}O_3$ (71) Paraldehyde	
15	1.31
20	1.17
C_6H_{14} (16) Diisopropyl	
0	0.495
15	0.409
20	0.385
25	0.361
30	0.342
C_6H_{14} (13) *n*-Hexane	
25	0.3289
35	0.2828
50	0.2746
65	0.2177
(91)	
0.80	0.3931
9.15	0.3581
14.75	0.3378
19.98	0.3202
25.39	0.3035
30.23	0.2894
36.76	0.2722
43.47	0.2557
47.42	0.2470
52.90	0.2351
58.76	0.2231
63.59	0.2143
A = 276.01 B = 189.42 n = 2.1264	
C_6H_{14} (16) Isohexane	
0	0.371
15	0.324
20	0.310
25	0.295
30	0.280
C_6H_{14} (16) 2, 2-Dimethylbutane	
0	0.477
15	0.397
20	0.375
25	0.351
30	0.330

t, °C	100η
C_6H_{14} (91) 2-Methylpentane	
0.61	0.3688
5.59	0.3487
10.25	0.3316
15.26	0.3147
20.51	0.2987
25.45	0.2841
31.97	0.2670
36.63	0.2550
41.07	0.2450
45.38	0.2355
51.17	0.2235
55.43	0.2151
A = 917.96 B = 209.35 n = 2.3237	
C_6H_{14} (16) 3-Methylpentane	
0	0.394
15	0.339
25	0.307
30	0.292
$C_6H_{14}O$ (30) Ethylisopropyl carbinol	
25	4.0_5
$C_6H_{14}O$ (31) Hexyl alcohol	
25	0.437
50	0.216
$C_6H_{14}O$ (30) Methylbutyl carbinol	
25	3.9_9
$C_6H_{14}O$ (92) Ethyl isobutyl ether	
0.36	0.4803
7.34	0.4397
15.10	0.4003
21.70	0.3709
28.14	0.3454
35.39	0.3200
41.76	0.2996
48.97	0.2791
55.99	0.2615
63.17	0.2440
70.66	0.2280
77.48	0.2147
A = 98.4046 B = 152.69 n = 1.9733	
$C_6H_{14}O$ (92) Propyl ether	
0.58	0.5359
8.58	0.4826
16.95	0.4358
24.65	0.3985
32.45	0.3654
40.47	0.3360
48.06	0.3114
56.14	0.2876
64.16	0.2664
72.59	0.2469

$C_6H_{14}O$.—(*Cont'd*)

t, °C	100η
81.47	0.2284
88.01	0.2154
A = 104.068 B = 148.362 n = 1.9734	
$C_6H_{14}O$ (39) Isopropyl ether	
20	0.322
$C_6H_{15}N$ (34) Triethylamine	
−33.5	0.7726
(72)	
25	0.363
$C_7H_5Cl_3$ (21) Benzotrichloride	
10	3.07
17	2.05
C_7H_5N (18) Benzonitrile	
25	1.25
C_7H_5N (9) Phenyl isocyanide	
0.28	1.957
10	1.615
20	1.330
30	1.133
40	0.983
50	0.863
60	0.767
70	0.687
80	0.622
100	0.514
C_7H_5NS (59) Phenyl thiocyanate	
25	1.4
35	1.2
50	0.98
C_7H_6O (18) Benzaldehyde	
25	1.40
$C_7H_6O_2$ (86) Salicylaldehyde	
45	1.798
$C_7H_6O_2$ (26) Benzoic acid	
122.5	1.6_7
130	1.2_6
C_7H_7NO (27) Formanilide	
120	1.6_5
(65)	
55	8.70
C_7H_8 (46) Toluene	
20.6	0.583
78.2	0.323
100	0.272
(50)	
25	0.5520
(60)	
25	0.5512

C_7H_8.—(*Cont'd*)

t, °C	100η
(91)	
0.26	0.7655
9.88	0.6683
19.47	0.5900
30.25	0.5184
39.86	0.4667
49.43	0.4219
60.18	0.3799
69.13	0.3503
80.59	0.3164
91.74	0.2877
99.95	0.2695
107.08	0.2554
A = 18.954 B = 112.99 n = 1.6522	
C_7H_8O (39) Benzyl alcohol	
20	5.582
(83)	
25	5.054
30	4.326
35	3.739
40	3.288
45	2.906
50	2.574
C_7H_8O (14.5) *o*-Cresol	
0	39.7
10	17.9
20	9.56
30	6.12
40	4.10
60	2.24
80	1.43
110	0.89
C_7H_8O (14.5) *m*-Cresol	
0	84.4
10	34.6
20	16.9
30	9.47
40	5.92
60	2.99
80	1.80
110	1.02
C_7H_8O (14.5) *p*-Cresol	
0	98.4
10	39.6
20	18.9
30	10.5
40	6.54
60	3.28
80	1.93
110	1.08
C_7H_8O (5) Phenyl methyl ether	
25	1.01
C_7H_9N (72) Benzylamine	
25	1.5_9
130	0.44_2

t, °C	100η
C_7H_9N (32) 2, 6-Lutidine	
25	0.88_1
C_7H_9N (9); *cf.* (59, 72, 87) Methylaniline	
0.3	4.265
10	3.065
20	2.303
30	1.811
40	1.466
50	1.215
70	0.886
C_7H_9N (9); *cf.* (72, 87) *o*-Toluidine	
0.31	10.105
10	6.428
20	4.392
30	3.194
40	2.436
50	1.919
60	1.578
70	1.302
80	1.109
90	0.952
100	0.831
C_7H_9N (72) *m*-Toluidine	
25	3.31
130	0.50
(87)	
55	1.5_1
C_7H_9N (87) *p*-Toluidine	
55	1.5_6
(72)	
130	0.52
(14)	
39.9	2.08
59.9	1.39
79.8	1.01
99.9	0.77_6
125	0.60_8
150	0.49_1
175	0.42_3
C_7H_9NO (87) *o*-Anisidine	
55	2.2_1
C_7H_9NO (87) *p*-Anisidine	
55	3.2_1
$C_7H_{12}O$ (42.5) *o*-Methylcyclohexanone	
17.3	1.82
39.1	1.21
65.9	0.83
$C_7H_{12}O$ (42.5) *m*-Methylcyclohexanone	
17.3	1.83
39.1	1.22
65.9	0.85

$C_7H_{12}O$ (42.5)
p-Methylcyclohexanone

t, °C	100η
17.3	1.83
39.1	1.23
65.9	0.87
90	0.69

$C_7H_{12}O$ (75)
Methylcyclohexanone

20	1.76

$C_7H_{12}O$ (88)
Suberone

25	2.59

$C_7H_{12}O_2$ (88)
Ethyl cyclobutanecarboxylate

25	0.996

$C_7H_{12}O_2$ (88)
Hexahydrobenzoic acid

50	8.38

$C_7H_{12}O_4$ (26)
Diethyl malonate

25	1.88

C_7H_{14} (16)
Methylcyclohexane

0	0.976
15	0.780
30	0.627

$C_7H_{14}O$ (39)
Diethylacetone

20	0.6989

$C_7H_{14}O$ (42.5)
o-Hexahydrocresol

39.1	6.97
65.9	2.56
90	1.26
(99)	
20	21.8

$C_7H_{14}O$ (99)
m-Hexahydrocresol

20	23.0

$C_7H_{14}O$ (99)
p-Hexahydrocresol

20	30.7

$C_7H_{14}O$ (88)
Dipropyl ketone

25	0.685

$C_7H_{14}O$ (39)
Methylpropylacetone

20	0.8398

$C_7H_{14}O$ (87)
Methyl *n*-amyl ketone

25	0.766

$C_7H_{14}O_2$ (87)
α-Ethylvaleric acid

25	3.80
50	2.06

$C_7H_{14}O_2$ (39)
Heptylic acid

t, °C	100η
20	4.357
(24)	
17.5	4.60
20	4.33
25	3.80
50	2.30
70	1.61
90	1.19

$C_7H_{14}O_2$ (53)
n-Amyl acetate

11	1.58
(6)	
25	0.811

$C_7H_{14}O_2$ (39)
Ethyl *n*-valerate

20	0.8362
(31)	
25	0.76
50	0.536

$C_7H_{14}O_2$ (87)
Ethyl α-methylbutyrate

25	0.675

$C_7H_{14}O_2$ (31)
Isobutyl propionate

25	0.67

$C_7H_{14}O_2$ (39)
Propyl *n*-butyrate

20	0.8296

$C_7H_{14}O_2$ (39)
Propyl isobutyrate

20	0.7389

C_7H_{16} (91)
n-Heptane

6.43	0.4797
6.56	0.4795
13.45	0.4418
21.74	0.4027
30.27	0.3685
38.34	0.3397
47.25	0.3112
55.03	0.2890
62.04	0.2714
70.09	0.2526
77.70	0.2372
85.49	0.2218
92.21	0.2096

A = 445.97
B = 180.14
n = 2.1879

(60)	
25	0.3855

C_7H_{16} (91)
2-Methylhexane

0.42	0.4743
7.70	0.4343
15.88	0.3959
24.63	0.3607
32.31	0.3333
40.05	0.3092
49.01	0.2839

C_7H_{16}.—(*Cont'd*)

t, °C	100η
56.46	0.2651
63.92	0.2484
71.84	0.2316
80.66	0.2149
88.41	0.2012

A = 362.79
B = 180.47
n = 2.1633

$C_7H_{16}O$ (39)
n-Heptyl alcohol

20	7.009
(31)	
25	5.68
50	2.68
90	1.00

$C_7H_{16}O$ (30)
n-Propylisopropyl carbinol

25	4.76

$C_7H_{16}O$ (30)
Methylamyl carbinol

25	5.08

C_8H_6 (48)
Phenylacetylene

25	0.886

C_8H_7N (26)
Benzyl cyanide

25	1.98

C_8H_8 (48)
Styrene

25	1.11

C_8H_8O (14.6)
Acetophenone

16	1.99
25	1.67
(57)	
25	1.67
50	1.24
95	0.653
(74.5)	
25	1.67
(49)	
25	1.681

$C_8H_8O_2$ (18)
Methoxybenzaldehyde

25	4.22

$C_8H_8O_2$ (26)
Phenylacetic acid

77	3.54
130	1.40

$C_8H_8O_2$ (39)
Methyl benzoate

20	2.067

$C_8H_8O_2$ (86)
Phenyl acetate

45	1.832

C_8H_9Cl (26)
β-Chloroethylbenzene

t, °C	100η
25	1.92

C_8H_9NO (65)
Form-*o*-toluide

55	12.91

C_8H_9NO (27)
Acetanilide

120	2.22
(72)	
130	1.90

C_8H_{10} (91)
Ethylbenzene

0.41	0.869
11.41	0.744
21.66	0.654
32.90	0.572
47.11	0.491
60.51	0.430
73.81	0.381
83.62	0.349
95.60	0.316
107.97	0.287
119.19	0.263
131.40	0.241

A = 41.215
B = 121.68
n = 1.7616

(26)	
25	0.632

C_8H_{10} (91), *o*-Xylene

0.49	1.095
13.88	0.881
26.54	0.738
39.33	0.628
51.94	0.544
65.41	0.473
78.78	0.416
90.82	0.373
101.78	0.340
116.61	0.302
128.15	0.276
141.14	0.252

A = 19.644
B = 96.352
n = 1.6386

C_8H_{10}(91), *m*-Xylene

0.24	0.799
11.52	0.684
23.36	0.595
35.97	0.513
48.71	0.450
59.94	0.404
60.27	0.403
71.20	0.366
86.35	0.322
98.68	0.293
109.75	0.269
123.53	0.244
135.28	0.225

A = 19.395
B = 115.66
n = 1.6400

C_8H_{10} (91)
p-Xylene

t, °C	100η
8.28	0.752
20.53	0.639
31.23	0.561
41.85	0.498
53.59	0.441
64.87	0.396
77.27	0.353
88.87	0.320
100.84	0.290
111.83	0.267
123.26	0.245
135.21	0.225

A = 32.7453
B = 117.730
n = 1.7326

$C_8H_{10}O$ (26)
2-Phenylethyl alcohol

25	7.61
50	3.20

$C_8H_{10}O$ (86)
Benzyl methyl ether

45	1.042

$C_8H_{10}O$ (86)
o-Cresyl methyl ether

45	0.858

$C_8H_{10}O$ (86)
m-Cresyl methyl ether

45	0.885

$C_8H_{10}O$ (86)
p-Cresyl methyl ether

45	0.814

$C_8H_{10}O$ (39)
Phenetole

20	1.261
(51)	
25	1.158
(86)	
45	0.833
(14)	
0	1.86
9.9	1.53
20.2	1.24
29.6	1.03
40	0.875
60	0.687
80	0.558

$C_8H_{11}N$ (9)
Dimethylaniline

10	1.688
20	1.413
30	1.201
40	1.036
50	0.905
60	0.800
70	0.714

$C_8H_{11}N$.—(*Cont'd*)

t, °C	100η
80	0.642
90	0.579
98	0.537
(14)	
0	2.025
10	1.654
20	1.387
30	1.17
40	1.024
60	0.798
80	0.658
126	0.461
177	0.341

$C_8H_{11}N$ (9); *cf.* (72, 87)
N-Ethylaniline

0.27	4.123
10	2.979
20	2.251
40	1.434
60	1.013
80	0.766
90	0.674
100	0.603

$C_8H_{11}N$ (72)
α-Phenylethylamine

25	1.66

$C_8H_{11}N$ (72)
β-Phenylethylamine

25	3.07

$C_8H_{11}N$ (87)
Methyl-*o*-toluidine

55	1.17

$C_8H_{11}N$ (87)
Methyl-*p*-toluidine

55	1.22

$C_8H_{12}O_3$ (88)
Ethyl 1-acetylcyclopropanecarboxylate

25	1.73

$C_8H_{12}O_3$ (88)
Ethyl cyclopentanonecarboxylate

25	3.50

$C_8H_{12}O_4$ (86.5)
Diethyl fumarate

24.7	2.45

$C_8H_{12}O_4$ (86.5)
Diethyl maleate

24.7	3.01

C_8H_{14} (97)
n-Hexylacetylene

25	0.657

$C_8H_{14}O_3$ (39)
Methyl propylacetoacetate

20	2.339

$C_8H_{14}O_3$ (88)
Ethyl ethylacetoacetate

25	1.69

$C_8H_{14}O_3$ (88)
Ethyl dimethylacetoacetate

t, °C	100η
25	1.60

$C_8H_{14}O_4$ (26)
Diethyl succinate

25	2.41

C_8H_{16} (16)
o-Dimethylcyclohexane

C_8H_{16} (16)
m-Dimethylcyclohexane

C_8H_{16} (16)
p-Dimethylcyclohexane

$C_8H_{16}O$ (39)
Ethylpropylacetone

20	0.8482

$C_8H_{16}O_2$ (39)
n-Caprylic acid

20	5.7482
(31)	
50	2.62
70	1.84
90	1.30

$C_8H_{16}O_2$ (39)
Dipropylacetic acid

20	7.642

$C_8H_{16}O_2$ (31)
Hexan-β-ol acetate

25	0.944

$C_8H_{16}O_2$ (31)
Isobutyl *n*-butyrate

25	0.84

$C_8H_{16}O_2$ (39)
n-Propyl *n*-valerate

20	1.038

$C_8H_{16}O_2$ (39)
Propyl methylethylacetate

20	0.8479

C_8H_{18} (91)
n-Octane

0.25	0.700
12.18	0.594
22.92	0.520
32.96	0.463
43.89	0.411
54.73	0.367
66.46	0.328
77.82	0.296
88.33	0.269
98.52	0.247
109.07	0.227
122.07	0.204

$A = 171.82$
$B = 145.50$
$n = 2.029$

$C_8H_{18}O$ (39)
n-Octyl alcohol

t, °C	100η
20	8.925
(31)	
25	7.21
50	3.22
90	1.21

$C_8H_{18}O$ (87)
d-sec.-Octyl alcohol

25	6.33

$C_8H_{18}O$ (87)
l-sec.-Octyl alcohol

25	6.55

$C_8H_{18}O$ (87)
dl-sec.-Octyl alcohol

25	6.49

$C_8H_{18}O$ (29)
Isopropylbutyl carbinol

25	7.12

$C_8H_{18}O$ (39)
Isobutyl ether

20	0.7491

$C_8H_{18}O$ (31)
Ethyl hexyl ether

25	0.929
50	0.653

$C_8H_{19}N$ (72)
Diisobutylamine

25	0.687

C_9H_7N (72)
Isoquinoline

25	3.57

C_9H_7N (14)
Quinoline

9.8	4.80
20.1	3.64
29.9	2.94
40	2.38
60	1.67
80	1.25
125	0.786
175	0.547
(52)	
25	3.361

$C_9H_{10}O_2$ (86)
Benzyl acetate

45	1.423

$C_9H_{10}O_2$ (39)
Ethyl benzoate

20	2.238
(51)	
25	2.014
(79)	
25	2.03
50	1.28
70	0.95
(49, 50)	
25	1.986

$C_9H_{10}O_2$ (26)
β-Phenylpropionic acid

t, °C	100η
49.7	9.8
130	1.72

$C_9H_{10}O_3$ (86)
Ethyl salicylate

45	1.803

$C_9H_{10}OS$ (76)
Ethyl thiobenzoate

25	2.42

$C_9H_{10}S_2$ (76)
Ethyl dithiobenzoate

25	3.12

$C_9H_{11}Cl$ (26)
γ-Chloropropylbenzene

25	2.47

$C_9H_{11}N$ (87)
Allylaniline

55	1.41
(72)	
130	0.506

$C_9H_{11}N$ (72)
1, 2, 3, 4-Tetrahydroquinoline

25	5.25

$C_9H_{11}NO$ (27)
N-Methylacetanilide

120	0.82

$C_9H_{11}NO$ (65)
Ethylformanilide

55	2.42

$C_9H_{11}NO_2$ (87)
Ethyl anthranilate

55	3.26

$C_9H_{11}NO_2$ (65)
Phenylurethane

55	85.35

C_9H_{12} (26)
n-Propylbenzene

25	0.793

$C_9H_{12}O$ (26)
β-Phenylpropyl alcohol

25	15.6
50	52.3

$C_9H_{12}O$ (39)
Ethyl *o*-cresyl ether

20	1.449(?)

$C_9H_{12}O$ (39)
Ethyl *p*-cresyl ether

20	1.467

$C_9H_{12}O$ (39)
Propyl phenyl ether

20	1.588

$C_9H_{13}N$ (88)
Dimethyl-*o*-toluidine

55	0.88

$C_9H_{13}N$ (88)
Dimethyl-*p*-toluidine

t, °C	100η
55	0.86

$C_9H_{13}N$ (72)
Ethyl-*o*-toluidine

25	1.98
(88)	
25	2.00
55	1.10

$C_9H_{13}N$ (88)
Ethyl-*p*-toluidine

25	2.40
55	1.21

$C_9H_{13}N$ (88)
Methylethylaniline

55	0.97

$C_9H_{13}N$ (88)
n-Propylaniline

25	2.53

$C_9H_{13}N$ (26)
3-Phenylpropylamine

25	3.6
(72)	
25	3.9

$C_9H_{14}O$ (25)
Phorone

25	1.40

$C_9H_{14}O_4$ (86.5)
Diethyl citraconate

24.7	3.25

$C_9H_{14}O_4$ (86.5)
Diethyl mesaconate

24.7	2.40

$C_9H_{14}O_4$ (88)
Diethyl cyclopropane 1, 1-dicarboxylate

25	2.36

$C_9H_{14}O_6$ (65)
Triacetin

55	4.79

$C_9H_{16}O_2$ (88)
Ethyl cyclohexanecarboxylate

25	1.79

$C_9H_{16}O_3$ (39)
Methyl diethylacetoacetate

20	4.108

$C_9H_{16}O_3$ (39)
Methyl methylpropylacetoacetate

20	2.826

$C_9H_{16}O_3$ (39)
Ethyl propylacetoacetate

20	2.264

$C_9H_{16}O_3$ (39)
Ethyl methylethylacetoacetate

20	2.357

$C_9H_{16}O_4$ (88)
Diethyl dimethylmalonate

t, °C	100η
25	1.95

$C_9H_{16}O_4$ (26)
Diethyl glutarate

25	2.49

$C_9H_{18}O$ (39)
Dipropylacetone

20	1.282

$C_9H_{18}O_2$ (31)
Isobutyl *n*-valerate

25	1.01

$C_9H_{18}O_2$ (31)
Ethyl *n*-heptylate

25	1.11

$C_9H_{18}O_2$ (88)
Ethyl α-ethylvalerate

25	0.905

$C_9H_{18}O_2$ (39)
Propyl methylpropylacetate

20	1.128

$C_9H_{18}O_2$ (39)
Propyl diethylacetate

20	1.182

$C_9H_{18}O_2$ (39)
Ethyl ethylpropylacetate

20	0.994

$C_9H_{18}O_2$ (39)
Methyl dipropylacetate

20	1.204

$C_9H_{18}O_2$ (31)
Hexan-β-ol propionate

25	1.04

$C_9H_{18}O_2$ (31)
Heptan-β-ol acetate

25	1.17

$C_9H_{18}O_2$ (31)
Methyl octoate

25	1.26
50	0.846

$C_9H_{18}O_2$ (39)
Pelargonic acid

20	8.333
(24)	
20	8.08
25	7.00
50	3.79
70	2.41
90	1.73

C_9H_{20} (7)
n-Nonane

22.3	0.624

$C_9H_{20}O$ (30)
Amylisopropyl carbinol

25	7.32

$C_9H_{20}O$ (30)
Methylheptyl carbinol

t, °C	100η
25	8.31

$C_{10}H_8$ (57)
Naphthalene

80	0.886
90	0.759
(55)	
150	0.217
152	0.196

$C_{10}H_9N$ (90)
α-Naphthylamine

50	11.2
(72)	
130	1.44

$C_{10}H_9N$ (72)
β-Naphthylamine

130	1.34

$C_{10}H_{10}O_2$ (25)
Safrol

25	2.30

$C_{10}H_{10}O_2$ (25)
Isosafrol

25	4.00

$C_{10}H_{12}$ (88)
Tetrahydronaphthalene

25	2.14
(45)	
25	2.00
50	1.30
75	0.906

$C_{10}H_{12}O_2$ (48)
Eugenol

25	6.96

$C_{10}H_{12}O_2$ (48)
Isoeugenol

25	2.68

$C_{10}H_{12}O_2$ (26)
Ethyl phenylacetate

25	2.39

$C_{10}H_{12}O_3$ (87)
Ethyl mandelate

25	19.7

$C_{10}H_{13}N$ (87)
Methylallylaniline

55	1.068

$C_{10}H_{13}N$ (72)
5, 6, 7, 8-Tetrahydro-α-naphthylamine

130	1.18

$C_{10}H_{13}N$ (72)
5, 6, 7, 8-Tetrahydro-β-naphthylamine

130	1.08

$C_{10}H_{13}NO_2$ (65)
Methylphenylurethane

55	2.55

$C_{10}H_{14}$ (88)
o-Cymene

t, °C	100η
25	1.02

$C_{10}H_{14}$ (88)
n-Butylbenzene

25	1.05

$C_{10}H_{14}O$ (88)
d-Carvol

25	3.39

$C_{10}H_{14}O$ (39)
Propyl *o*-tolyl ether

20	2.014(?)

$C_{10}H_{15}N$ (9)
Diethylaniline

0.5	3.841
10	2.850
20	2.185
40	1.425
60	1.021
80	0.777
98	0.630

$C_{10}H_{16}O_4$ (88)
Diethylcyclobutane-1, 1-dicarboxylate

25	2.61

$C_{10}H_{18}$ (45)
Decahydronaphthalene

25	2.41
50	1.58
75	1.08

$C_{10}H_{18}O$ (88)
Menthone

25	2.31

$C_{10}H_{18}O_3$ (39)
Methyl ethylpropylacetoacetate

20	4.869

$C_{10}H_{18}O_3$ (39)
Ethyl methylpropylacetoacetate

20	2.720

$C_{10}H_{18}O_3$ (39)
Ethyl diethylacetoacetate

20	3.502

$C_{10}H_{18}O_4$ (88)
Diethyl methylethylmalonate

25	2.47

$C_{10}H_{18}O_4$ (26)
Diethyl adipate

25	2.78

$C_{10}H_{20}O$ (47)
Menthol

34.9	25.05
37.8	20.36
43.4	13.68
56.9	6.89

$C_{10}H_{20}O$.—(*Cont'd*)

t, °C	100η
(81)	
55.6	6.28
74.6	2.47
82.2	1.85
99	1.04

$C_{10}H_{20}O_2$ (31)
Butan-β-ol *n*-hexoate

25	1.27

$C_{10}H_{20}O_2$ (39)
Ethyl dipropylacetate

20	1.425

$C_{10}H_{20}O_2$ (31)
Ethyl *n*-caprylate

25	1.38
50	0.94

$C_{10}H_{20}O_2$ (31)
Hexan-β-ol *n*-butyrate

25	1.33

$C_{10}H_{20}O_2$ (31)
Heptan-β-ol propionate

25	1.25

$C_{10}H_{20}O_2$ (31)
Octan-β-ol acetate

25	1.52

$C_{10}H_{20}O_2$ (31)
n-Capric acid

50	4.34
70	2.88

$C_{10}H_{22}$ (7)
n-Decane

22.3	0.78

$C_{10}H_{22}$ (13)
2, 7-Dimethyloctane

25	0.8278
35	0.6702
50	0.5540
65	0.4686

$C_{10}H_{22}O$ (30)
Methyl-*n*-octyl carbinol

25	10.1

$C_{10}H_{22}O$ (30)
Isopropyl-*n*-hexyl carbinol

25	10.2

$C_{11}H_{14}O_2$ (26)
Ethyl β-phenylpropionate

25	3.07

$C_{11}H_{15}NO$ (6)
Acetoethyl-o-toluidine

25	9.99

$C_{11}H_{15}NO_2$ (65)
Ethylphenylurethane

55	2.76

$C_{11}H_{16}O$ (39)
Thymyl methyl ether

t, °C	100η
20	2.288(?)

$C_{11}H_{17}N$ (87)
Isoamylaniline

55	1.72

$C_{11}H_{20}$ (97)
Nonylacetylene

25	2.00

$C_{11}H_{20}O_4$ (26)
Diethyl *n*-pimelate

25	3.29

$C_{11}H_{22}O_2$ (26)
Undecylic acid

50	7.30

$C_{11}H_{22}O_2$ (31)
Hexan-β-ol *n*-valerate

25	1.56

$C_{11}H_{22}O_2$ (31)
Heptan-β-ol *n*-butyrate (31)

25	1.57

$C_{11}H_{22}O_2$ (31)
Octan-β-ol propionate

25	1.59

$C_{11}H_{22}O_2$ (31)
Ethyl pelargonate

25	1.69
50	1.11

$C_{11}H_{22}O_2$ (31)
Isobutyl *n*-heptoate

25	1.52

$C_{11}H_{22}O_2$ (39)
Propyl dipropylacetate

20	1.791

$C_{11}H_{22}O_2$ (39)
Ethyl diethylpropylacetate

20	3.861

$C_{11}H_{24}$ (7)
n-Undecane

22.7	0.94

$C_{11}H_{24}O$ (30)
Methylnonyl carbinol

25	12.3

$C_{12}H_{10}O$ (51)
Diphenyl ether

25	3.864
(79)	
25	3.66

$C_{12}H_{11}N$ (87)
Diphenylamine

55	4.66
(14)	
61	4.18
81	2.53
(72)	
130	1.04

$C_{12}H_{13}N$ (87)
Dimethyl-α-naphthylamine

t, °C	100η
55	3.25
(72)	
130	0.87

$C_{12}H_{13}N$ (87)
Dimethyl-β-naphthylamine

55	3.36
(72)	
130	0.95

$C_{12}H_{14}O_4$ (6)
Diethyl phthalate

25	10.1
(65)	
55	4.182

$C_{12}H_{16}O_2$ (39)
Propyl hydrocinnamate

20	3.9377

$C_{12}H_{17}NO_2$ (6)
Ethyl-*o*-tolylurethane

25	9.44

$C_{12}H_{18}O$ (39)
Thymyl ethyl ether

20	2.513(?)

$C_{12}H_{18}O_6$ (97)
Triethyl aconitate

25	11.7

$C_{12}H_{22}O_3$ (39)
Ethyl dipropylacetoacetate

20	4.829

$C_{12}H_{22}O_4$ (26)
Diethyl suberate

25	4.05

$C_{12}H_{24}O_2$ (24)
Lauric acid

50	7.3
60	5.61
70	4.43
80	3.62
90	2.99

$C_{12}H_{24}O_2$ (31)
Isobutyl *n*-octoate

25	1.82

$C_{12}H_{24}O_2$ (31)
Hexan-β-ol *n*-hexoate

25	1.80

$C_{12}H_{24}O_2$ (31)
Heptan-β-ol *n*-valerate

25	1.79

$C_{12}H_{24}O_2$ (31)
Octan-β-ol *n*-butyrate

25	1.89

$C_{12}H_{26}$ (7)
n-Dodecane

23.3	1.15

$C_{12}H_{26}O$ (30)
Octylisopropyl carbinol

t, °C	100η
25	14.4

$C_{13}H_{10}O$ (57)
Benzophenone

25	13.6
95	1.74
(65)	
55	4.67

$C_{13}H_{12}$ (57)
Diphenylmethane

100	0.83

$C_{13}H_{13}N$ (87)
Benzylaniline

55	5.39
(72)	
130	1.20

$C_{13}H_{13}N$ (14)
N-Methyldiphenylamine

9.8	11.0
20.1	7.25
30	5.15
40	3.85
60	2.49
80	1.74
(72)	
130	0.81

$C_{13}H_{20}O$ (39)
Thymyl propyl ether

20	3.527

$C_{13}H_{26}O_2$ (31)
Methyl laurate

25	3.08
50	1.85

$C_{13}H_{26}O_2$ (31)
Isobutyl *n*-nonate

25	2.18

$C_{13}H_{26}O_2$ (31)
Hexan-β-ol *n*-heptoate

25	2.15

$C_{13}H_{26}O_2$ (31)
Heptan-β-ol hexoate

25	2.19

$C_{13}H_{26}O_2$ (31)
Undecan-β-ol acetate

25	2.81

$C_{13}H_{28}$ (7)
n-Tridecane

23.3	1.52

$C_{14}H_{12}O_2$ (51)
Benzyl benzoate

25	8.504
(11)	
5	19.28
15	12.12
25	8.292

$C_{14}H_{12}O_2$.—(*Cont'd*)

t, °C	100η
40	5.243
60	3.259
80	2.245
90	1.912
100	1.655
(50)	
25	8.454

$C_{14}H_{15}N$ (72)
Dibenzylamine

25	6.16
130	0.812

$C_{14}H_{26}O_4$ (26)
Diethyl sebacate

25	5.1
(97)	
25	5.42

$C_{14}H_{28}O_2$ (24)
Myristic acid

60	7.43
70	5.83
80	4.64
90	3.81
(31)	
70	6.76
90	4.16

$C_{14}H_{28}O_2$ (31)
Ethyl laurate

25	3.08
50	1.74

$C_{14}H_{28}O_2$ (31)
Heptan-β-ol *n*-heptoate

25	2.56

$C_{14}H_{28}O_2$ (31)
Octan-β-ol *n*-hexoate

25	2.55

$C_{14}H_{28}O_2$ (31)
Undecan-β-ol propionate

25	2.84

$C_{14}H_{30}$ (7)
n-Tetradecane

21.9	2.22

$C_{15}H_{17}N$ (87)
Ethylbenzylaniline

55	4.77

$C_{15}H_{30}O_2$ (31)
Isobutyl *n*-undecate

25	3.25

$C_{15}H_{30}O_2$ (31)
Hexan-β-ol *n*-nonate

25	3.08

$C_{15}H_{30}O_2$ (31)
Heptan-β-ol *n*-octoate

25	3.03

$C_{15}H_{30}O_2$ (31)
Octan-β-ol *n*-heptoate

25	3.07

$C_{15}H_{30}O_2$ (31)
Undecan-β-ol
n-butyrate

t, °C	100η
25	3.62

$C_{15}H_{32}$ (7)
n-Pentadecane

22	2.86

$C_{16}H_{17}NO_2$ (65)
Benzylphenylurethane

55	10.96

$C_{16}H_{27}N$ (87)
Diisoamylaniline

55	2.92

$C_{16}H_{32}O_2$ (24)
Palmitic acid

70	7.8
80	6.1
90	5.0
95	4.47

$C_{16}H_{32}O_2$ (31)
Isobutyl laurate

25	3.87

$C_{16}H_{32}O_2$ (31)
Heptan-β-ol
n-nonoate

25	3.69

$C_{16}H_{32}O_2$ (31)
Octan-β-ol
n-octoate

25	3.64

$C_{16}H_{32}O_2$ (31)
Undecan-β-ol
n-valerate

25	3.74

$C_{16}H_{34}$ (7)
n-Hexadecane

22.2	3.63

$C_{16}H_{34}O$ (31)
Cetyl alcohol

50	14.6
90	3.53

$C_{17}H_{34}O_2$ (31)
Hexan-β-ol
undecoate

25	4.3

$C_{17}H_{34}O_2$ (31)
Octan-β-ol
n-nonoate

25	4.22

$C_{17}H_{34}O_2$ (31)
Undecan-β-ol
n-hexoate

t, °C	100η
25	4.14

$C_{18}H_{15}N$ (72)
Triphenylamine

130	6.4

$C_{18}H_{15}O_4P$ (65)
Triphenyl phosphate

55	9.50

$C_{18}H_{15}P$ (97)
Triphenylphosphine

100	4.62

$C_{18}H_{15}Sb$ (97)
Triphenylstibine

70	9.34

$C_{18}H_{36}O_2$ (24)
Stearic acid

70	9.87
80	7.72
90	6.1
95	5.47
98	5.18
(31)	
70	9.4
90	5.6

$C_{18}H_{36}O_2$ (31)
Ethyl palmitate

25	5.76
50	3.14

$C_{18}H_{36}O_2$ (31)
Isobutyl myristate

25	5.32

$C_{18}H_{36}O_2$ (31)
Hexan-β-ol
laurate

25	5.4

$C_{18}H_{36}O_2$ (31)
Heptan-β-ol
n-undecoate

25	5.15

$C_{18}H_{36}O_2$ (31)
Undecan-β-ol
n-heptoate

25	4.91

$C_{19}H_{16}$ (57)
Triphenylmethane

95	3.5
100	3.22

$C_{19}H_{38}O_2$ (31)
Heptan-β-ol
laurate

t, °C	100η
25	5.9

$C_{19}H_{38}O_2$ (31)
Octan-β-ol
undecoate

25	5.82

$C_{20}H_{38}O_2$ (86.5)
Ethyl elaidate

24.7	8.17

$C_{20}H_{38}O_4$ (97)
Diisoamyl sebacate

25	12.0

$C_{20}H_{40}O_2$ (31)
Ethyl stearate

50	3.75

$C_{20}H_{40}O_2$ (31)
Hexan-β-ol
myristate

25	6.73

$C_{20}H_{40}O_2$ (31)
Octan-β-ol
laurate

25	6.87

$C_{20}H_{40}O_2$ (31)
Undecan-β-ol
nonoate

25	6.61

$C_{21}H_{21}N$ (72)
Tribenzylamine

130	2.09

$C_{21}H_{42}O_2$ (31)
Heptan-β-ol
myristate

25	7.75

$C_{22}H_{44}O_2$ (31)
Octan-β-ol
myristate

25	8.91

$C_{22}H_{44}O_2$ (31)
Undecan-β-ol
undecoate

25	8.73

$C_{23}H_{46}O_2$ (31)
Undecan-β-ol
laurate

25	9.66

$C_{25}H_{50}O_2$ (31)
Undecan-β-ol
myristate

25	12.3

INFLUENCE OF PRESSURE ON VISCOSITY (14.7)

η = viscosity of liquid under tabulated pressure and temperature.

$\eta_{30°}$ = viscosity of liquid at 30° and atmospheric pressure; poises.

P = pressure in kg/cm².

The reference value of $\eta_{30°}$ is indicated under the name of compound.

Values of $\log_{10} \frac{\eta}{\eta_{30°}}$

CCl_4, Carbon tetrachloride
$\eta_{30°} = 0.00845$

P, kg/cm²	30°	75°
1	0.000	9.760
500	0.190	9.949
1 000	0.351	0.100
4 000		0.542

CS_2, Carbon disulfide
$\eta_{30°} = 0.00352$

1	0.000	9.875
500	0.090	9.972
1 000	0.160	0.051
2 000	0.307	0.180
4 000	0.509	0.372
6 000	0.674	0.527
8 000	0.840	0.671
10 000	1.010	0.808
12 000	1.189	0.946

$CHCl_3$, Chloroform
v. Vol. V, p. 11

CH_4O, Methyl alcohol
v. Vol. V, p. 11

$C_2H_4Br_2$, Ethylene bromide
$\eta_{30°} = 0.0149$

1	0.000	9.756
500	0.138	9.885
1 000		0.003
2 000		0.203

C_2H_5Br, Ethyl bromide
$\eta_{30°} = 0.00368$

1	0.000	9.806
500	0.121	9.959
1 000	0.222	0.072
2 000	0.387	0.235
4 000	0.631	0.472
6 000	0.854	0.653
8 000	1.043	0.816
10 000	1.223	0.978
12 000	1.400	1.123

C_2H_5Cl, Ethyl chloride

1	0.000	9.850
500	0.134	0.017
1 000	0.242	0.131
2 000	0.405	0.285
4 000	0.649	0.514
6 000	0.837	0.683
8 000	1.008	0.834
10 000	1.172	0.977
12 000	1.323	1.111

C_2H_5I, Ethyl iodide
$\eta_{30°} = 0.00540$

P, kg/cm²	30°	75°
1	0.000	9.837
500	0.115	9.954
1 000	0.218	0.057
2 000	0.385	0.227
4 000	0.656	0.467
6 000	0.888	0.672
8 000	1.108	0.854
10 000	1.330	1.030
12 000	1.549	1.200

C_2H_6O, Ethyl alcohol
v. Vol. V, p. 11

C_3H_6O, Acetone
$\eta_{30°} = 0.00285$

1	0.000	9.895
500	0.135	0.017
1 000	0.226	0.113
2 000	0.373	0.245
4 000	0.605	0.445
6 000	0.804	0.610
8 000	0.987	0.762
10 000	1.160	0.898
12 000		1.031

C_3H_8O, *n*-Propyl alcohol
$\eta_{30°} = 0.01779$

1	0.000	9.598
500	0.151	9.754
1 000	0.283	9.880
2 000	0.494	0.074
4 000	0.836	0.368
6 000	1.131	0.610
8 000	1.402	0.827
10 000	1.667	1.033
12 000	1.915	1.223

C_3H_8O, Isopropyl alcohol
$\eta_{30°} = 0.01757$

1	0.000	9.505
500	0.193	9.695
1 000	0.343	9.851
2 000	0.591	0.087
4 000	0.982	0.425
6 000	1.318	0.701
8 000	1.640	0.957
10 000	1.977	1.191
12 000	2.311	1.424

$C_3H_8O_3$, Glycerol

$\eta_{30°} = 3.8$

P, kg/cm²	30°	75°
1	0.000	8.810
500	0.134	8.920
1 000	0.260	9.023
2 000	0.497	9.204
4 000	0.936	9.529
6 000	1.346	9.818
8 000	1.741	0.094
10 000	2.133	0.369
12 000		0.628

$C_4H_8O_2$, Ethyl acetate

$\eta_{30°} = 0.0039$

1	0.000	9.836
500	0.142	9.976
1 000	0.258	0.081
2 000	0.463	0.253
4 000	0.818	0.517
6 000	1.120	0.761
8 000	1.393	0.992
10 000	1.686	1.213
12 000	1.974	1.416

C_4H_9Br, *n*-Butyl bromide

$\eta_{30°} = 0.00537$

1	0.000	9.832
500	0.143	9.975
1 000	0.269	0.090
2 000	0.474	0.273
4 000	0.816	0.564
6 000	1.115	0.811
8 000	1.408	1.040
10 000	1.715	1.264
12 000	2.018	1.484

$C_4H_{10}O$, *n*-Butyl alcohol

$\eta_{30°} = 0.02237$

1	0.000	9.548
500	0.175	9.724
1 000	0.321	9.867
2 000	0.554	0.089
4 000	0.934	0.312
6 000	1.289	0.690
8 000	1.609	0.941
10 000	1.912	1.172
12 000	2.208	1.396

$C_4H_{10}O$, Isobutyl alcohol

$\eta_{30°} = 0.02864$

1	0.000	9.444
500	0.210	9.659
1 000	0.388	9.824
2 000	0.696	0.075
4 000	1.203	0.488
6 000	1.655	0.838
8 000	2.075	1.158
10 000	2.483	1.459
12 000	2.898	1.747

$C_4H_{10}O$, Ethyl ether

v. Vol. V, p. 11

C_5H_{12}, Isopentane

$\eta_{30°} = 0.00198$

1	0.000	9.821
500	0.202	0.040
1 000	0.344	0.193

C_5H_{12}.—(*Continued*)

P, kg/cm²	30°	75°
2 000	0.559	0.408
4 000	0.894	0.715
6 000	1.175	0.960
8 000	1.431	1.179
10 000	1.687	1.381
12 000	1.947	1.586

C_5H_{12}, *n*-Pentane

$\eta_{30°} = 0.00220$

1	0.000	9.811
500	0.181	0.014
1 000	0.315	0.163
2 000	0.524	0.380
4 000	0.847	0.676
6 000	1.112	0.908
8 000	1.360	1.119
10 000	1.615	1.313
12 000	1.846	1.493

$C_5H_{12}O$, Isoamyl alcohol

1	0.000	9.424
500	0.209	9.618
1 000	0.386	9.787
2 000	0.686	0.065
4 000	1.185	0.492
6 000	1.636	0.848
8 000	2.069	1.168
10 000	2.505	1.483
12 000	2.952	1.780

$C_5H_{12}O$, *n*-Amyl alcohol

1	0.000	9.540
500	0.188	9.723
1 000	0.341	9.871
2 000	0.607	0.105
4 000	1.060	0.466
6 000	1.448	0.772
8 000	1.811	1.049
10 000	2.164	1.313
12 000	2.495	1.562

C_6H_5Br, Bromobenzene

$\eta_{30°} = 0.00985$

1	0.000	9.801
500	0.138	9.930
1 000	0.262	0.044
2 000	0.486	0.228
4 000	0.897	0.558
6 000		0.874

C_6H_5Cl, Chlorobenzene

$\eta_{30°} = 0.00711$

1	0.000	9.814
500	0.133	9.936
1 000	0.253	0.053
2 000	0.478	0.245
4 000	0.867	0.563
6 000	1.223	0.852
8 000		1.146
10 000		1.465

$C_6H_5NO_2$, Nitrobenzene

1	0.000	
500	0.134	
1 000	0.264	

C_6H_6, Benzene

v. Vol. V, p. 12

C_6H_{12}, Cyclohexane

$\eta_{30°} = 0.00828$

P, kg/cm²	30°	75°
1	0.000	9.723
500	0.261	9.975
1 000		0.169

C_6H_7N, Aniline

$\eta_{30°} = 0.0319$

1	0.000	9.551
500	0.195	9.703
1 000	0.376	9.847
2 000	0.709	0.102
4 000		0.560

C_6H_{14}, *n*-Hexane

$\eta_{30°} = 0.00296$

1	0.000	9.803
500	0.184	0.028
1 000	0.332	0.171
2 000	0.561	0.379
4 000	0.914	0.701
6 000	1.224	0.961
8 000	1.514	1.198
10 000	1.803	1.426
12 000		1.646

C_7H_8, Toluene

$\eta_{30°} = 0.00523$

1	0.000	9.796
500	0.145	9.939
1 000	0.274	0.065
2 000	0.497	0.267
4 000	0.897	0.597
6 000	1.285	0.896
8 000	1.699	1.186
10 000	2.177	1.504
12 000		1.832

C_7H_{14}, Methylcyclohexane

$\eta_{30°} = 0.00639$

1	0.000	9.747
500	0.220	9.976
1 000	0.388	0.154
2 000	0.710	0.434
4 000	1.274	0.900
6 000	1.804	1.335
8 000	2.318	1.756
10 000		2.167
12 000		2.582

C_8H_{10}, *o*-Xylene

$\eta_{30°} = 0.00709$

1	0.000	9.767
500	0.165	9.925
1 000	0.311	0.057
2 000	0.577	0.292
4 000		0.689
6 000		1.087

C_8H_{10}, *m*-Xylene

$\eta_{30°} = 0.00552$

1	0.000	9.799
500	0.154	9.959
1 000	0.290	0.079
2 000	0.529	0.286
4 000	0.967	0.637
6 000		0.983
8 000		1.333

C_8H_{10}, *p*-Xylene

$\eta_{30°} = 0.00568$

P, kg/cm²	30°	75°
1	0.000	9.797
500	0.152	9.957
1 000		0.092
2 000		0.315

C_8H_{18}, *n*-Octane

$\eta_{30°} = 0.00483$

1	0.000	9.810
500	0.196	0.003
1 000	0.327	0.153
2 000	0.641	0.390
4 000	1.088	0.763
6 000	1.487	1.080
8 000		1.363
10 000		1.630

$C_{10}H_{12}O_2$, Eugenol

1	0.000	9.429
500	0.288	9.616
1 000	0.541	9.810
2 000	1.081	0.143
3 000	2.273	0.805
5 000		1.520
8 000		2.343

$C_{10}H_{14}$, *p*-Cymene

1	0.000	9.800
500	0.172	9.948
1 000	0.333	0.087
2 000	0.626	0.335
4 000	1.194	0.749
6 000	1.859	1.168
8 000		1.612
10 000		2.164

$C_{10}H_{15}N$, Diethylaniline

1	0.000	9.690
500	0.201	9.839
1 000	0.394	9.984
2 000	0.761	0.259
4 000		0.758
6 000		1.250
8 000		1.775

$C_{10}H_{18}O$, Cineole

1	0.000	9.654
500	0.315	9.905
1 000		0.142
2 000		0.575

$C_{10}H_{22}O$, *n*-Amyl ether

1	0.000	9.736
500	0.218	9.943
1 000	0.401	0.107
2 000	0.708	0.364
4 000	1.230	0.776
6 000	1.685	1.125
8 000	2.091	1.437
10 000		1.728
12 000		2.007

$C_{18}H_{34}O_2$, Oleic acid

1	0.000	9.419
500	0.306	9.671
1 000	0.616	9.989
2 000		0.255
4 000		0.843

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FREE ENERGY OF CHEMICAL SUBSTANCES, ACTIVITY COEFFICIENTS, PARTIAL MOLAL QUANTITIES, AND RELATED CONSTANTS[1]

MERLE RANDALL, SPECIAL EDITOR

Including

EQUILIBRIA BETWEEN TWO SOLID PHASES AND A GAS PHASE (DECOMPOSITION PRESSURES OF HYDRATES, AMMONIATES, ETC.)

FRITZ EPHRAIM[2]

and

SOLUBILITY OF SLIGHTLY SOLUBLE SALTS IN AQUEOUS SALT SOLUTIONS

MERLE RANDALL AND WILLIAM V. VIETTI[3]

SCOPE OF THE SECTION

This section includes all chemical equilibria except those which have been treated in previous sections. The section also includes miscellaneous thermodynamic data, such as partial molal quantities, activity coefficients, heat capacities of substances, etc., when these are combined with other data.

The tables are not as complete as could be desired. An attempt has been made to include as many types of systems as possible, and more space has been given to those systems which have not been widely discussed in the literature than to the more common systems. Omission of a table or mention by reference only in no way reflects upon the quality or importance of the data.

OBJET TRAITÉ DANS LA SECTION

Cette section comprend tous les équilibres chimiques, à l'exception de ceux dont il a déjà été traité dans des sections précédentes. La section renferme aussi des données thermodynamiques diverses, telles que des quantités moléculaires partielles, coefficients d'activité, capacités calorifiques des substances, etc., lorsque celles-ci sont combinées à d'autres données.

Les tables ne sont pas aussi complètes qu'on puisse le désirer. On s'est efforcé d'y mentionner un nombre aussi grand que possible de types de systèmes, et il a été réservé plus d'espace aux systèmes qui n'ont pas été largement discutés dans la littérature qu'aux systèmes plus communs. L'omission d'une table ou sa mention par une référence seulement ne se rapporte en aucune manière à la qualité ou à l'importance de la donnée.

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[1] *See also* Entropy, etc., Vol. V, p. 84.

[2] Editorial Note.—The data on this topic, compiled by Professor Ephraim, have been combined with the other data of this section according to the Standard Arrangement. They are identified by the symbol (E). Translation from the German and conversion into the units °K and atm. were effected by Gerald F. Breckenridge under the direction of the Special Editor.

[3] The senior author is alone responsible for the data on the complex ammines and for references subsequent to the year 1925. For this section, *see* p. 313.

ARRANGEMENT

1. The systems or reactions are listed in the standard arrangement (*see* Vol. III, p. viii) in accordance with that substance in the reaction which has the highest key-formula. Thus, for example, in the reaction

$$Pb(s) + PbO_2(s) + 2H_2SO_4(aq) = 2PbSO_4(s) + 2H_2O(l)$$

the key-formulae are:

Pb, 23; PbO_2, 23—12; H_2SO_4, 8—22—14; $PbSO_4$, 23—8—14; H_2O, 22—1.

The highest key-formula is that for $PbSO_4$, 23—8—14 and this reaction will therefore be found listed under $PbSO_4$ and can be found by turning the pages until 23 appears as the first member of the key-numbers which appear at the top of each right-hand page. After locating the proper section in this way, the desired system or reaction can then be located by inspection.

2. Where choice of condition or state is involved for a given substance the order is gas (g); liquid (l); solid (s); in aqueous solution (aq); in non-aqueous solution, standard arrangement by solvents.

3. *Important Exceptions.*—Solid hydrates, ammines, etc., containing water, ammonia, etc., "of crystallization" are listed under the parent material. Water, ammonia, etc., of crystallization should, therefore, be neglected in writing key-formulae. (These exceptions do not, however, apply to complex ions, complex cobaltammines, etc.) Solubility data are in all cases listed under the solute.

SYMBOLS AND ABBREVIATIONS

In general the notation of Lewis and Randall (885) is used.

a	Activity.
c	Concentration (moles per liter).
$c_\pm$	Geometrical mean of concentration of ions.
f	Fugacity.
het.	Two-phase system richest in solute.
ln	Logarithm to the base *e*.
log	Logarithm to the base 10.
m	Molality (moles per 1000 g H_2O, *in vacuo*).
$m_\pm$ $m^0_\pm$	*v.* p. 227.
n	Number of moles.
p	Vapor pressure (in atmospheres).
p.f.	Proportionality factor (*see* activity coefficients).
s	Solubility (moles per 1000 g H_2O, *in vacuo*).
s_c	Solubility (moles per liter).
t	Temperature, °C.
x	Mole fraction.
C_p	Molal heat capacity at constant pressure.
C_v	Molal heat capacity at constant volume.
E	Internal energy.
E	Electromotive force.
E^-	One gram atom of negative electricity.
F	Free energy.
H	Heat content.
I	Integration constant.
K	Equilibrium constant (activities) *v.* p. 227.
K'	Special equilibrium function.
K_c	Equilibrium function in terms of concentration.
K_m	Equilibrium function in terms of molalities.
K_p	Equilibrium function in terms of partial pressures.
$\bar{L}$	Relative partial molal heat content.
M	Molal.
P	Total pressure or vapor pressure, in atmospheres.
R	Gas constant.
S	Entropy.
T	Absolute temperature.
V	Volume.
w	Molal mass.

ARRANGEMENT

1. Les systèmes ou les réactions sont disposés en liste suivant l'arrangement type (*voir* Vol. III, p. viii) en accord avec la substance de la réaction qui possède la formule-clé la plus élevée. Ainsi, par exemple, dans la réaction

$$Pb(s) + PbO_2(s) + 2H_2SO_4(aq) = 2PbSO_4(s) + 2H_2O(l)$$

les formules-clés sont

Pb, 23; PbO_2, 23—12; H_2SO_4, 8—22—14; $PbSO_4$, 23—8—14; H_2O, 22—1.

La formule-clé la plus élevée est celle de $PbSO_4$, 23—8—14 et par conséquent on trouvera la réaction mentionnée ci-dessus sous $PbSO_4$; on tournera donc les pages jusqu'à ce qu'on atteigne 23, premier membre des nombres-clés inscrits au haut de chacune des pages se trouvant à main droite. Ayant trouvé de cette façon la section convenable, on y recherchera alors, le système de réaction désiré.

2. Lorsque le choix de la condition ou de l'état est impliqué pour une substance donnée, l'ordre est gaz (g); liquide (l); solide (s); en solution aqueuse (aq); en solution non-aqueuse, arrangement type par dissolvants.

3. *Exceptions Importantes.*—Les hydrates solides, les ammines, etc., contenant de l'eau, de l'ammoniaque, etc., "de cristallisation" sont inscrits en liste sous la matière principale. L'eau, l'ammoniaque, etc., de cristallisation doivent donc être négligés lorsqu'on écrit la formule-clé. (Ces exceptions cependant ne s'appliquent pas aux ions complexes, cobaltammines complexes, etc.) Les données de solubilité sont dans tous les cas inscrits sous le corps dissous.

SYMBOLES ET ABRÉVIATIONS

C'est en général la notation de Lewis et Randall (885) quies utilisée.

a	Activité.
c	Concentration (mol gr. par litre).
$c_\pm$	Moyenne géométrique de la concentration des ions.
f	Fugacité.
het.	Système à deux phases le plus riche en corps dissous.
ln	Logarithme de base *e*.
log	Logarithme de base 10.
m	"Molalité" (mol gr. par 1000 g H_2O, dans le vide).
$m_\pm$ $m^0_\pm$	*v.* p. 227.
n	Nombre de molécules grammes.
p	Pression de vapeur (en atmosphères).
p.f.	Facteur de proportionalité (*voir* coefficients d'activité).
s	Solubilité (molécules gr. par 1000 g H_2O, dans le vide).
s_c	Solubilité (molécules gr. par litre).
t	Température, °C.
x	Fraction moléculaire gramme.
C_p	Capacité calorifique moléculaire à pression constante.
C_v	Capacité calorifique moléculaire à volume constant.
E	Énergie interne.
E	Force électromotrice.
E^-	Un atome gramme d'électricité négative.
F	Énergie libre.
H	Contenu de chaleur.
I	Constante d'intégration.
K	Constante d'équilibre (activités), *v.* p. 227.
K'	Fonction d'équilibre spéciale.
K_c	Fonction d'équilibre en termes de concentration.
K_m	Fonction d'équilibre en termes de molalité.
K_p	Fonction d'équilibre en termes de pressions partielles.
$\bar{L}$	Contenu de chaleur relatif partiel moléculaire.
M	Moléculaire gramme.
P	Pression totale ou pression de vapeur, en atmosphères.
R	Constante des gaz.

γ	Activity coefficient.
μ	Ionic strength.
μ_c	Ionic strength (for concentrations).
ν	Number of ions formed by dissociation of one molecule.
Δ	Increment.

Small cap roman: molal quantities, thus H.

Small cap roman with bar: Partial molal quantity, thus $\bar{\text{H}}$.

Subscript $_1$ (resp. $_2$) identifies solvent (resp. solute).

UNITS AND VALUES OF CONSTANTS USED*

1 cal.	4.182 joules.
T	$t + 273.1$.
R	82.07 cm^3-atm. per deg. K.
R	1.9885 cal. per deg. K.
V	(for 1 mole of a perfect gas) 22 412 cm^3 at 1 atm. and 273.1°K.
F	96 494 coulombs per equiv.
F	23 074 cal. per volt equiv.

All pressures are expressed in atmospheres, all temperatures in degrees absolute, all electromotive forces in volts and all energy quantities in calories (*v. supra*) unless otherwise expressly stated. When making further transformations of the data, it is important to use only the constants and data of this section.

FREE ENERGY DATA

In general, the accuracy of the free energy equations may be judged by the constancy of the quantity I where this has been tabulated. The lack of a definite trend with a variation in temperature indicates that the choice of the particular form of substances taking part in the reaction and the values of the ΔH and ΔC_p are probably substantially correct. The individual variations indicate the degree of precision of the experimental measurements. Since many of the derived values involve addition and subtraction of other equations, it is not possible, at this time, to give the probable error, and the number of significant figures given should not be interpreted as an indication of the accuracy. Where "revised" values are indicated, it is usually necessary to use the unrevised (885) values, when these are to be combined with other equations in this section.

The free energies are given in the form

$$\Delta F^0 = \Delta H_0^0 - \Delta\Gamma_0^0 T \ln T - \tfrac{1}{2}\Delta\Gamma' T^2 - \tfrac{1}{6}\Delta\Gamma'' T^3 - \cdot\cdot\cdot + IT \tag{1}$$

where $\Delta\Gamma$, $\Delta\Gamma'$ and $\Delta\Gamma''$, etc., are the coefficients in the algebraic expression for the increase in heat capacity of the reaction.

We thus have

$$\Delta H^0 = \Delta H_0^0 + \Delta\Gamma^0 T + \tfrac{1}{2}\Delta\Gamma' T^2 + \tfrac{1}{3}\Delta\Gamma'' T^3 \tag{2}$$

$$\Delta S^0 = \Delta\Gamma_0^0(1 + \ln T) + \Delta\Gamma' T + \tfrac{1}{2}\Delta\Gamma'' T^2 + \cdot\cdot\cdot - I \tag{3}$$

The superscript ^{0} on the quantities ΔF, ΔH, ΔS indicates that the quantity is that for a stated or implied reaction in which all chemical substances involved are assumed to be at unit activity, at a fugacity of 1 atm. (or, when specifically so stated, at a pressure of 1 atm.), or hypothetical unit concentration. Where the reaction is not explicitly stated it is assumed to be the reaction of formation of a stated substance out of its elements in their standard states. The standard state of an element is that state to which the value $\Delta F^0 = 0$ is assigned in the tables, the pressure being always one atm. unless otherwise specifically stated. When no standard state is thus indicated in the tables, the "ordinary" solid form of the element is assumed.

In writing the equilibrium constant, K, the activities of the substances appearing on the right of the reaction as written always appear in the numerator. For gases the units are always atmospheres, and for solutes the units are always mole fractions, or moles per 1000 g of water. For the constant K so defined, $\Delta F^0 = -RT \ln K$.

S	Entropie.
T	Température absolue.
V	Volume.
W	Masse molale.
γ	Coefficient d'activité.
μ	Force ionique.
μ_c	Force ionique (pour concentrations).
ν	Nombre d'ions formées par dissociation d'un molécule.
Δ	Incrément.

Petite majuscule romaine: Quantités moléculaires, ainsi H.

Petite majuscule romaine avec barre: Quantité moléculaire partielle, ainsi $\bar{\text{H}}$.

L'indice $_1$ (resp. $_2$) identifie le solvant (resp. le corps dissous).

UNITÉS ET VALEURS DES CONSTANTES UTILISÉES*

1 cal.	4,182 joules.
T	$t + 273,1$.
R	82,07 cm^3-atm. par deg. K.
R	1,9885 cal. par deg. K.
V	(pour une molécule gramme d'un gaz parfait) 22 412 cm^3 à 1 atm. et à 273, 1°K.
F	96 494 coulombs par equiv.
F	23 074 cal. par volt equiv.

Toutes les pressions sont exprimées en atmosphères, toutes les températures en degrés absolus, toutes les forces électromotrices en voltes et toutes les quantités d'énergie en calories (*v.* ci-dessus), à moins d'une autre indication. Lorsqu'on veut effectuer des transformations ultérieures des données, il est important de n'utiliser que les constantes et les données de cette section.

DONNÉES RELATIVES À L'ÉNERGIE LIBRE

En général, on peut juger de la précision des équations relatives à l'énergie libre par la constance de la quantité I en consultant la table où celle-ci est mentionnée. Le manque d'une tendance définie avec la variation de la température indique que le choix de la forme particulière des substances prenant part à la réaction et des valeurs de ΔH et ΔC_p est probablement réellement exact. Les variations individuelles indiquent le degré de précision des mesures expérimentales. Comme plusieurs des valeurs dérivées comportent l'addition et la soustraction d'autres équations, il n'est pas possible, pour le moment, de donner l'erreur probable et le nombre de chiffres significatifs donnés ne doit pas être interprété comme une indication de la précision. Lorsque des valeurs "revised" sont indiquées, il est ordinairement nécessaire d'utiliser les valeurs non revisées (885), lorsque celles-ci doivent être combinées avec d'autres équations de la section.

Les énergies libres sont données sous la forme

$$\Delta F^0 = \Delta H_0^0 - \Delta\Gamma_0^0 T \ln T - \tfrac{1}{2}\Delta\Gamma' T^2 - \tfrac{1}{6}\Delta\Gamma'' T^3 - \cdot\cdot\cdot + IT \tag{1}$$

où $\Delta\Gamma$, $\Delta\Gamma'$ et $\Delta\Gamma''$, etc., sont les coefficients dans l'expression algébrique de l'augmentation de la capacité calorifique de la réaction.

On a ainsi

$$\Delta H^0 = \Delta H_0^0 + \Delta\Gamma^0 T + \tfrac{1}{2}\Delta\Gamma' T^2 + \tfrac{1}{3}\Delta\Gamma'' T^3 \tag{2}$$

$$\Delta S^0 = \Delta\Gamma_0^0(1 + \ln T) + \Delta\Gamma' T + \tfrac{1}{2}\Delta\Gamma'' T^2 + \cdot\cdot\cdot - I \tag{3}$$

L'exposant ^{0} sur les quantités ΔF, ΔH, ΔS, indique que la quantité est celle se rapportant à une reaction établie ou implicite, dans laquelle toutes les substances chimiques engagées sont supposées être à l'activité unité, à une fugacité d'une atmosphère, (ou, lorsque cela est établi spécifiquement ainsi, à une pression d'une atm.), ou à une concentration unité hypothétique. Lorsque la réaction n'est pas établie explicitement, il s'agit d'une réaction de formation d'une substance donnée à partir de ses éléments dans leur état type. L'état type d'un élément est l'état pour lequel la

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* Note that these *are not* the accepted I. C. T. values (*see* Vol. I, p. 17). The data of the present section form a consistent whole but cannot be readily combined with other data in I. C. T.

* À noter que celles-ci *ne sont pas* les valeurs I. C. T. acceptées (*voir* Vol. I, p. 17). Les données de la présente section constituent un tout consistant, mais elles ne peuvent être directement combinées avec les autres données dans les I. C. T.

In some cases we use equilibrium functions (K_m) in which the molality of the substances or ions is used instead of the activity, and others (K_c) in which the concentrations (moles per liter) of the substances in solution are used instead of the activities. In still others we have used special functions (K'_m or K'_c) in which activities are used for all the substances except the ions present. The concentration of a gas is never used in these expressions. *See* Lewis and Randall (885), Randall and Vietti (1192), Randall (1170.5).

ACTIVITY COEFFICIENTS

In the case of all reactions involving only ions on the right-hand side of the equation, and a few others, the various equilibria are transformed in such a way that (log γ + a constant) and $\mu^{1/2}$ are given in the tables. By a simple graph of these quantities interpolations and comparisons may be made, and by superimposition of the curves so obtained upon the corresponding curves for suitable reference salts made upon the same scale, the extrapolation to unit activity coefficient can be easily made, and when these extrapolated numbers become available the activity coefficient of the particular pair of ions may be found by subtraction of log *p.f.* (given in a few cases) from the value of (log γ + a constant). The activity coefficient for concentration, the ionic strength for concentration, etc., are defined in the sense used by Randall and Vietti (1192), namely, the product of the-activity-coefficient-for-concentration by the concentration gives the activity (defined with reference to molalities).

$$\log \gamma + \text{const.} = \log \gamma - E^0/(0.00019844\nu T/N) = -E/(0.00019844\nu T/N) + \log (1/m_\pm) \quad (4)$$

where E^0 and E are the standard and measured electromotive forces, N the number of equivalents, and $m_\pm$ the mean molality of the ions studied in the cell.* Or

$$\log \gamma + \text{const.} = (1/\nu) \log p + \log (1/m_\pm) \quad (5)$$

where p is the vapor pressure of the solute. Or

$$\log \gamma + \text{const.} = (1/\nu) \log x_2 + \log (1/m_\pm)$$

where x_2 is the mole fraction of the solute in a second immiscible solvent. Or

$$\log \gamma + \text{const.} = \log (1/m_\pm)$$

where $m_\pm$ is the mean molality of the ions in equilibrium with the pure solid (solubility). Or

$$\log \gamma + \text{const.} = (1/\nu) \log (1/K'_m),$$

where K'_m is an equilibrium function in which activities are substituted for all substances taking part in the reaction (usually undissociable substances or gases) except the pair of ions considered. (*See* $CaCO_3$ (calcite) + H_2CO_3(aq) = Ca^{++} + $2HCO_3^-$, p. 296.)

INHALT DIESER ABTEILUNG

Zu dieser Abteilung gehören alle Gleichgewichte bis auf solche welche in den vorhergehenden behandelt worden sind. Die Abteilung enthält auch verschiedene thermodynamische Daten wie partielle molare Grössen, Aktivitätskoeffizienten, Molwärmen der Substanzen, usw., wenn dieselben mit anderen Daten verbunden sind.

Die Tabellen sind nicht so vollständig wie man sich wünschen könnte. Es wurde versucht, möglichst verschiedenartige Systeme zu behandeln; jenen Systemen, welche in der Literatur nicht so ausführlich diskutiert worden sind, ist mehr Raum gewidmet als den gewöhnlicheren. Das Weglassen einer Tabelle, oder die blosse Zitierung einer Arbeit ist nie als eine Unterschätzung der Qualität oder Wichtigkeit der Daten zu betrachten.

ANORDNUNG

1. Die Systeme und Reaktionen sind nach der Standardanordnung (*siehe* Bd. III, S. viii) geordnet, dem Reaktionsteilnehmer mit der höchsten Schlüsselformel entsprechend. So sind zum

valeur $\Delta F^0 = 0$ est assignée dans les tables, la pression étant toujours une atm. à moins d'une autre indication. Lorsque aucun état type n'est indiqué ainsi dans les tables, il s'agit de la forme "ordinaire" solide de l'élément.

En écrivant la constante d'équilibre, K, les activités des substances se trouvant au deuxième membre de la réaction sont écrites au numérateur comme d'habitude. Pour les gaz, les unités sont toujours atmosphères, et pour les corps dissous, les unités sont toujours fractions moléculaires grammes, ou molécules grammes pour 1000 g d'eau. Pour la constante K, ainsi définie, $\Delta F^0 = -RT \ln K$.

Dans quelques cas on s'est servi des fonctions d'équilibre (K_m), dans lesquelles la molalité des substances ou des ions est utilisée à la place de l'activité, et d'autres fonctions (K_c) dans lesquelles les concentrations (mol gr. par litre) des substances en solutions sont utilisées à la place des activités. Dans d'autres cas encore, il a été employé des fonctions spéciales (K'_m ou K'_c) dans lesquelles les activités ont été utilisées pour toutes les substances à l'exception des ions présents. La concentration d'un gaz n'est jamais utilisée dans ces expressions. *Voir* Lewis et Randall (885), Randall et Vietti (1192), Randall (1170.5).

COEFFICIENTS D'ACTIVITÉ

Dans le cas de toutes les réactions ne comportant que des ions au deuxième membre de l'équation, et dans quelques autres cas, les divers équilibres sont transformés de telle façon que (log γ + une constante) et $\mu^{1/2}$ soient donnés dans les tables. Au moyen d'un simple graphique de ces quantités, on peut faire des interpolations et des comparaisons et par superposition des courbes ainsi obtenues avec les courbes correspondantes de sels de référence convenables, dessinées à la même échelle, on peut effectuer facilement l'extrapolation pour le coefficient unité d'activité; lorsque ces nombres extrapolés sont disponibles, on trouvera le coefficient d'activité de la paire particulière d'ions en soustrayant log *p.f.* (donné dans quelques cas) de la valeur de (log γ + une constante). Le coefficient d'activité pour la concentration, la force ionique pour la concentration, etc., sont définis suivant le sens utilisé par Randall et Vietti (1192), c'est-à-dire, le produit du coefficient d'activité pour la concentration, par la concentration donne l'activité (définie avec référence aux molalité).

$$\log \gamma + \text{constante} = \log \gamma - E^0/0{,}00019844\nu T/N) = -E/(0{,}00019844\nu T/N) - \log (1/m_\pm) \quad (4)$$

où E^0 et E sont respectivement les forces électromotrices types et mesurées, N le nombre des équivalents et $m_\pm$ la molalité moyenne des ions étudiés dans la pile.* Ou

$$\log \gamma + \text{constante} = (1/\nu) \log p + \log (1/m_\pm) \quad (5)$$

où p est la pression de vapeur du corps dissous. Ou

$$\log \gamma + \text{constante} = (1/\nu) \log x_2 + \log (1/m_\pm)$$

où x_2 est la fraction moléculaire du corps dissous dans un deuxième dissolvant non miscible. Ou

$$\log \gamma + \text{constante} = \log (1/m_\pm)$$

où $m_\pm$ est la molalité moyenne des ions en équilibre avec le solide pur (solubilité). Ou

$$\log \gamma + \text{constante} = (1/\nu) \log (1/K'_m)$$

où K'_m est une fonction d'équilibre dans laquelle les activités sont substituées à toutes les substances prenant part à la réaction (ordinairement des substances non dissociables ou des gaz), à l'exception de la paire d'ions considérés. (*Voir* $CaCO_3$ (calcite) + H_2CO_3(aq) = Ca^{++} + $2HCO_3^-$, p. 296.)

ARGOMENTI COMPRESI IN QUESTO CAPITOLO

Questo capitolo comprende tutti gli equilibri chimici, eccettuati quelli dei quali si è parlato in capitoli precedenti. Vi sono pure contenuti dati termodinamici diversi, come quantità molari parziali, coefficienti di attività, capacità termiche, ecc.

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* In general $\Delta F = -NEF$.

* En général $\Delta F = -NEF$.

Beispiel in der Reaktion

$$Pb(s) + PbO_2(s) + 2H_2SO_4(aq) = 2PbSO_4(s) + 2H_2O(l)$$

die folgenden als Schlüsselformeln zu nehmen:

Pb, 23; PbO_2, 23−12; H_2SO_4, 8−22−14; $PbSO_4$, 23−8−14; H_2O, 22−1.

Die höchste Schlüsselformel ist jene für $PbSO_4$, 23−8−14, und diese Reaktion wird deswegen unter $PbSO_4$ angegeben; man kann sie auffinden, indem man die Blätter des Bandes umschlägt, bis 23 als das erste Glied der Schlüsselnummern, die am oberen Ende jeder rechten Seite sind, erscheint. Nachdem die richtige Abteilung so gefunden worden ist, kann man das erwünschte System oder die erwünschte Reaktion nach Besichtigung festsetzen.

2. Wo es sich um eine Zustandswahl für die gegebene Substanz handelt, ist die Ordnung wie folgt: Gas (g); Flüssigkeit (l); fester Körper (s); in wässriger Lösung (aq); in nicht-wässriger Lösung, Standardanordnung nach Lösungsmitteln.

3. *Wichtige Ausnahmen.*—Feste Hydrate, Ammine, usw., Krystallwasser oder Krystall-Ammoniak enthaltend, stehen unter dem lösungsmittel-freien Salz verzeichnet. Krystall-Wasser, -Ammoniak, usw., sind deswegen im Schreiben der Schlüsselformeln fortzulassen. (Diese Ausnahmen sind aber für Komplexionen, Komplexkobaltammine, usw., nicht gültig.) Löslichkeitsdaten sind immer unter der Schlüsselformel des gelösten Stoffes zu finden.

ZEICHEN UND ABKÜRZUNGEN

Im allgemeinen werden die Formelzeichen von Lewis und Randall (885) gebraucht. (*Siehe* auch die deutsche Übersetzung von Redlich.)

a	Aktivität.
c	Konzentration (Mol pro Liter).
$c_\pm$	Geometrisches Mittel der Ionenkonzentrationen.
f	Flüchtigkeit. (Fugazität).
het.	Zwei-Phasen System am reichsten an gelöstem Stoff.
ln	Natürlicher Logarithmus.
log	Dekadischer Logarithmus.
m	Molarer Gehalt (Mol pro 1000 g H_2O *in vacuo*, Molarität).
$m_\pm$ $m_\pm^0$	*Siehe* S. 230.
n	Molzahl.
p	Dampfdruck (in Atmosphären).
$p.f.$	Proportionalitätsfaktor (*siehe* Aktivitätskoeffizienten).
s	Löslichkeit (Mol pro 1000 g H_2O *in vacuo*).
s_c	Löslichkeit (Mol pro Liter).
t	Temperatur, Grad Celsius.
x	Molenbruch.
C_p	Molwärme bei konstantem Druck.
C_v	Molwärme bei konstantem Volumen.
E	Innere Energie.
E	Elektromotorische Kraft.
E^-	Ein Gramm-Atom Äquivalent negativer Elektrizität.
F	Freie Energie.
H	Wärmeinhalt.
I	Integrationskonstante.
K	Gleichgewichtskonstante (Aktivitäten) *siehe* S. 230.
K'	Spezielle Gleichgewichtsfunktion.
K_c	Gleichgewichtsfunktion in Konzentrationen ausgedrückt.
K_m	Gleichgewichtsfunktion in Molaritäten ausgedrückt.
K_p	Gleichgewichtsfunktion in Partieldrücken ausgedrückt.
L	Relativer partieller molare Wärmeinhalt.
M	Molar.
P	Gesamtdruck oder Dampfdruck in Atmosphären.
R	Gaskonstante.
S	Entropie.
T	Absolute Temperatur.
V	Volumen.
W	Molare Masse (Molekulargewicht).

Le tabelle però non sono così complete come si potrebbe desiderare. Si è cercato di includervi il maggior numero possibile di tipi di sistemi, e sono stati trattati con maggiore estensione i sistemi non ampiamente discussi nella letteratura, anzichè quelli più comuni. Il fatto che qualche tabella sia stata omessa o che dei dati siani stati semplicemente citati non indica nulla rispetto alla qualità e alla importanza di essi.

DISPOSIZIONE

1. I sistemi e le reazioni sono elencate con l'ordinamento standard (*vedi* Vol. III, p. viii) seguendo l'ordine delle sostanze che hanno la formula-chiave più alta. Così, per esempio, nella reazione

$$Pb(s) + PbO_2(s) + 2H_2SO_4(aq) = 2PbSO_4(s) + 2H_2O(l)$$

le formule-chiavi sono:

Pb, 23; PbO_2, 23—12; H_2SO_4, 8—22—14; $PbSO_4$, 23—8—14; H_2O, 22—1.

La formula-chiave più alta è quella del $PbSO_4$, 23—8—14 e quindi questa reazione si troverà elencata sotto $PbSO_4$ e si troverà dove il 23 apparirà come il primo membro dei numeri-chiave che stannò in cima ad ogni pagina di destra. Stabilita a questo modo la sezione si può trovare il sistema di reazione per ispezione.

2. Quando una data sostanza è considerata in diversi stati, allora l'ordine è il seguente: gas (g); liquido(l); solido(s) in soluzione acquosa (aq); in soluzione non acquosa l'ordine è quello standard dei solventi.

3. *Eccezioni Importanti.*—Gli idrati solidi, le ammine, ecc., che contengono acqua, ammoniaca, ecc. "di cristallizzazione" sono elencati sotto la sostanza originaria. L'acqua, l'ammoniaca, ecc., di cristallizzazione dovrà essere tralasciata nello scrivere la formula-chiave. (Queste eccezioni non si riferiscono tuttavia agli ioni complessi, alle cobaltammine complesse, ecc.) I dati di solubilità sono in ogni caso elencati sotto i soluti.

ABBREVIAZIONI E SIMBOLI

In genere viene impiegata l'annotazione di Lewis e Randall (885).

a	Attività.
c	Concentrazioni (moli per litro).
$c_\pm$	Media geometrica della concentrazione degli ioni.
f	Fugacità.
het.	Sistema di due fasi più ricco in soluto.
ln	Logaritmo a base e.
log	Logaritmo a base 10.
m	Molarità (moli per 1000 g di H_2O, nel vuoto).
$m_\pm$ $m_\pm^0$	*v.* p. 230.
n	Numero di moli.
p	Tensione di vapore (in atmosfere).
$p.f.$	Fattore di proporzionalità (*vedi* coefficienti di attività).
s	Solubilità (moli per 1000 g H_2O, nel vuoto).
s_c	Solubilità (moli per litro).
t	Temperatura, °C.
x	Frazione di mole.
C_p	Capacità termica molare a pressione costante.
C_v	Capacità termica molare a volume costante.
E	Energia interna.
E	Forza elettromotrice.
E^-	Un grammo atomo di elettricità negativa.
F	Energia libera.
H	Contenuto termico.
I	Costante d'integrazione.
K	Costante di equilibrio (attività) *v.* p. 230.
K'	Funzione speciale di equilibrio.
K_c	Funzione d'equilibrio espressa in concentrazioni.

γ	Aktivitätskoeffizient.
μ	Ionenstärke.
μ_c	Ionenstärke (für Konzentrationen).
ν	Anzahl Ionen, die bei Dissoziation einer Molekül gebildet werden.
Δ	Zuwachs.

Kleingedruckte lateinische Grossbuchstaben, z. B. H, bedeuten molare Grössen.

Kleingedruckte lateinische Grossbuchstaben überstrichen, z. B. $\overline{\text{H}}$, bedeuten partielle molare Grössen.

Index $_1$ (bezw. $_2$) entspricht dem Lösungsmittel (bezw. gelöstem Stoff).

EINHEITEN UND WERTE DER GEBRAUCHTEN KONSTANTEN*

1 cal.	4,182 Joule.
T	$t + 273,1$.
R	82,07 cm^3-Atm. pro Grad K.
R	1,9885 Kal. pro Grad K.
V	(für einem Mol eines idealen Gases) 22 412 cm^3 bei 1 Atm. und 273,1°K.
F	96 494 Coulomb pro Äquiv.
F	23 074 Kal. pro Volt Äquiv.

Alle Drucke sind in Atmosphären, alle Temperaturen in Grad absolut, alle elektromotorischen Kräfte in Volt, und alle Energiegrössen in Kalorien (*siehe* weiter oben) ausgedrückt, wenn nicht ausdrücklich anders angegeben ist. Bei weiterer rechnerischer Verwendung dieser Daten ist es wichtig nur die Konstanten und Daten dieser Abteilung zu gebrauchen.

DATEN DER FREIEN ENERGIE

Im allgemeinen kann man die Genauigkeit der Gleichungen für die freie Energie nach der Konstanz der Grösse I beurteilen, wenn letztere tabellarisiert ist. Das Ausbleiben einer bestimmten Richtung der Konstante bei einer Temperaturänderung zeigt, dass die Wahl dieser besonderen Formen der Reaktionsteilnehmer, sowohl wie die Werte von ΔH und ΔC_p wahrscheinlich richtig ist. Die einzelnen Abweichungen zeigen den Präzisionsgrad der experimentellen Messungen. Da viele der abgeleiteten Werte durch Addition und Subtraktion anderer Gleichungen erhalten worden sind, ist es zu dieser Zeit nicht möglich, die Grösse des wahrscheinlichsten Fehlers anzugeben; die Zahl der angegebenen Ziffern soll deswegen nicht als Mass der Genauigkeit genommen werden. Wo "revised" Werte angegeben sind, ist es gewöhnlich nötig dass man die nicht revidierten (^{885}) Werte gebraucht, wenn man solche Daten mit anderen der Abteilung kombinieren will.

Die freien Energien sind in folgender Form gegeben

$$\Delta F^0 = \Delta H_0^0 - \Delta\Gamma_0^0 T \ln T - \tfrac{1}{2}\Delta\Gamma' T^2 - \tfrac{1}{6}\Delta\Gamma'' T^3 - \ldots + IT \quad (1)$$

wo $\Delta\Gamma$, $\Delta\Gamma'$, $\Delta\Gamma''$, usw., die Koeffizienten in dem algebräischen Ausdruck für die Zunahme des Wärmeinhalts während der Reaktion sind.

So haben wir

$$\Delta H^0 = \Delta H_0^0 + \Delta\Gamma^0 T + \tfrac{1}{2}\Delta\Gamma' T^2 + \tfrac{1}{3}\Delta\Gamma'' T^3 \quad (2)$$

$$\Delta S^0 = \Delta\Gamma_0^0(1 + \ln T) + \Delta\Gamma' T + \tfrac{1}{2}\Delta\Gamma'' T^2 + \ldots - I \quad (3)$$

Der Index ^{0} an den Grössen ΔF, ΔH, ΔS bedeutet dass die Grösse zu einer angegebenen oder angedeutenden Reaktion gehört, in welcher alle teilnehmenden chemischen Substanzen bei Aktivität Eins, bei einer Flüchtigkeit von 1 Atm. (oder, wenn es besonders angegeben ist, bei einem Druck von 1 Atm.), oder bei

K_m	Funzione d'equilibrio espressa in molarità.
K_p	Funzione d'equilibrio in termini delle pressioni parziali.
$\overline{\text{L}}$	Contenuto termico molare relativo parziale.
M	Molare.
P	Pressione totale o tensione di vapore in atmosfere.
R	Costante dei gas.
S	Entropia.
T	Temperatura assoluta.
V	Volume.
W	Massa molale.
γ	Coefficiente di attività.
μ	Forza ionica.
μ_c	Forza ionica per le concentrazioni.
ν	Numero degli ioni formatisi per la dissociazione d'una molecula.
Δ	Incremento.

Let. cap. rom. piccola. Quantità molari, per esempio H.

Let. cap. rom. pic. sbarrata. Quantità molari parziali, per esempio $\overline{\text{H}}$.

L'indicazione sottoscritta $_1$ (risp. $_2$) si riferisce al solvente (risp. soluto).

UNITÀ E VALORI DELLE COSTANTI IMPIEGATE*

1 cal.	4,182 joules.
T	$t + 273,1$.
R	82,07 cm^3-atm. per grado K.
R	1,9885 cal. per grado K.
V	(per una mole di gas perfetto) 22 412 cm^3 a 1 atm. e 273,1°K.
F	96 494 coulombs per equiv.
F	23 074 cal. per volt equiv.

Tutte le pressioni sono espresse in atmosfere, tutte le temperature in gradi assoluti, tutte le forze elettromotrici in volte e tutte le quantità di energia in calorie (*v.* sopra) a meno che non venga espressamente altrimenti indicato. Nel fare ulteriori trasformazioni dei dati è importante che vengano usati solo le costanti e i dati di questo capitolo.

DATI SULL'ENERGIA LIBERA

In genere, l'accuratezza delle equazioni dell'energia libera può essere giudicata dalla costanza di I, dove questo è riportato. Quando il valore di I non mostra tendenza a variare con la temperatura deve ritenersi che la scelta delle forme particolari delle sostanze prendenti parte alla reazione, e i valori di ΔH e ΔC_p sono da ritenersi con probabilità sostanzialmente corretti. Le singole variazioni indicano il grado di accuratezza delle misure sperimentali. Siccome molti dei valori dedotti implicano la addizione e la sottrazione di altre equazioni, non è possibile, oggi, indicare l'errore probabile; non bisogna prendere quindi come indice di accuratezza il numero delle cifre riportate. Dove sono riportati valori "revised" bisognerà usare i valori non corretti (^{885}) quando dovranno essere combinati con altre equazioni di questo capitolo.

Le energie libere sono date nella forma

$$\Delta F^0 = \Delta H_0^0 - \Delta\Gamma_0^0 T \ln T - \tfrac{1}{2}\Delta\Gamma' T^2 - \tfrac{1}{6}\Delta\Gamma'' T^3 - \cdots + IT \quad (1)$$

dove $\Delta\Gamma$, $\Delta\Gamma'$ e $\Delta\Gamma''$, ecc., sono i coefficienti dell'incremento della capacità termica della reazione nell'espressione algebrica.

Così si ha:

$$\Delta H^0 = \Delta H_0^0 + \Delta\Gamma^0 T + \tfrac{1}{2}\Delta\Gamma' T^2 + \tfrac{1}{3}\Delta\Gamma'' T^3 \quad (2)$$

$$\Delta S^0 = \Delta\Gamma_0^0(1 + \ln T) + \Delta\Gamma' T + \tfrac{1}{2}\Delta\Gamma'' T^2 + \cdots - I \quad (3)$$

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* Es ist zu beachten das diese Werte nicht diejenigen sind welche sonst in den I. C. T. (*siehe* Bd. I, S. 17) angenommen wurden. Die Daten dieser Abteilung bilden unter sich ein einheitliches System, aber können nicht leicht mit anderen Daten in den I. C. T. kombiniert werden.

* Nota bene che questo *non sono* i valori accettati dalle I. C. T. (*vedi* Vol. I, p. 17). I dati di questa sezione formano un tutto unico, ma non possono essere combinati senz'altro con gli altri dati delle I. C. T.

einer hypothetischen Konzentration Eins angenommen sind. Ist die Reaktion nicht ausdrücklich angegeben, so wird angenommen, dass es sich um jene Reaktion handelt, in welcher eine gegebene Substanz aus ihren Elementen in dessen Normalzuständen gebildet wird. Der Normalzustand ist jener, welchem in den Tabellen der Wert $\Delta F^0 = 0$ zugeteilt ist, wobei der Druck immer 1 Atm. sein soll, falls kein anderer Wert dafür besonders angegeben wird. Im Fall, dass kein Normalzustand in den Tabellen derart angegeben ist, nimmt man den "gewöhnlichen" festen Zustand des Elementes an.

Die Gleichgewichtskonstante, K, ist immer so definiert, dass die Aktivitäten der Substanzen, welche rechts in der geschriebenen Reaktionsgleichung erscheinen, im Zähler stehen, Für Gase sind die Einheiten immer Atmosphäre, und für gelöste Stoffe immer Molenbrüche, oder Mol pro 1000 g Wasser. Für die Konstante K auf diese Weise definiert, ist $\Delta F^0 = -RT \ln K$.

In einigen Fällen gebrauchen wir Gleichgewichtsfunktionen (K_m), in welchen, anstatt Aktivitäten, die Molarität der Substanzen oder Ionen gebraucht wird, und anderere (K_c) in welchen die Aktivitäten durch Konzentrationen (Mol pro Liter) ersetzt sind. In noch anderen Fällen haben wir Spezialfunktionen (K'_m oder K'_c) gebraucht, in welchen für alle Substanzen, ausser den Ionen, Aktivitäten benutzt worden sind. Die Konzentration eines Gases kommt in solchen Ausdrücken nie vor. *Siehe* Lewis und Randall (**885**), Randall und Vietti (**1192**), und Randall (**1170.5**).

AKTIVITÄTSKOEFFIZIENTEN

Im Falle aller Reaktionen, welche auf der rechten Seite nur Ionen enthalten, und etlicher anderer, sind die verschiedenen Gleichgewichte so umgeformt, dass (log γ + Konstante) und $\mu^{1/2}$ in den Tabellen angegeben sind. Durch einfache graphische Auftragung dieser Grössen, kann man Interpolieren und Vergleiche ausführen; durch Auflegen der so erhaltenen Kurven auf entsprechende Kurven in demselben Massstabe für passende Bezugssalze kann man leicht zum Aktivitätskoeffizienten Eins extrapolieren. Wenn diese extrapolierten Grössen vorhanden sind, kann der Aktivitätskoeffizient für das betreffende Ionenpaar durch Subtraktion von log *p.f.* (in einigen Fällen angegeben) von dem Wert der Grösse (log γ + Konstante) erhalten werden. Der Aktivitätskoeffizient für Konzentration, die Ionenstärke für Konzentration, usw., sind in dem Sinne Randall und Viettis (**1192**) definiert, nämlich so, dass die Aktivität (in Bezug auf Molaritäten definiert) gleich ist dem Produkt von dem besagten Konzentrationsaktivitätskoeffizient und der Konzentration.

$$\log \gamma + \text{Konstante} = \log \gamma - E^0/(0{,}00019844\nu\ T/N) = E/(0{,}00019844\nu\ T/N) + \log (1/m_\pm) \qquad (4)$$

wo E^0 die normalen und E die gemessenen elektromotorischen Kräfte, N die Nummer der Äquivalenten, und $m_\pm$ die mittlere Molarität der Ionen in der Kette bedeutet*. Oder

$$\log \gamma + \text{Konstante} = (1/\nu) \log p + \log (1/m_\pm) \qquad (5)$$

wo p der Dampfdruck des gelösten Stoffes ist. Oder

$$\log \gamma + \text{Konstante} = (1/\nu) \log x_2 + \log (1/m_\pm)$$

wo x_2 den Molenbruch gelösten Stoffes in einem zweiten unvermischbaren Lösungsmittel bedeutet. Oder

$$\log \gamma + \text{Konstante} = \log (1/m_\pm)$$

wo $m_\pm$ die mittlere Molarität der Ionen in Gleichgewicht mit dem reinen festen Stoffe (Löslichkeit) ist. Oder

$$\log \gamma + \text{Konstante} = (1/\nu) \log (1/K'_m)$$

wo K'_m eine Gleichgewichtsfunktion ist, in welcher für alle Reaktionsteilnehmer (am gewöhnlichsten undissozierbare Stoffe oder Gase) bis auf das betrachtete Ionenpaar, Aktivitäten eingesetzt worden sind. (*Siehe* $CaCO_3$(Calcite) + H_2CO_3 (aq) = Ca^{++} + $2HCO_3^-$, S. 296.)

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* In allgemeinen $\Delta F = NEF$.

Il contrassegno ^{0} sulle quantità ΔF, ΔH, ΔS, indica che esse si riferiscono ad una reazione in cui tutte le sostanze che vi partecipano vengono considerate a una attività unitaria, a una fugacità di 1 atm. (oppure, quando sia specificamente indicato, alla pressione di 1 atmosfera) o a una concentrazione unitaria ipotetica. Quando la reazione non è esplicitamente indicata, si suppone sia quella di formazione di una data sostanza dagli elementi, nei loro stati standard. Lo stato standard di un elemento è quello per il quale nelle tabelle viene dato il valore $\Delta F^0 = 0$, la pressione essendo sempre di 1 atm. salvo che non venga altrimenti indicato. Quando nelle tabelle non è indicato nessuno stato standard, si tratta della forma solida "ordinaria" dell'elemento.

Nello scrivere la costante di equilibrio, K, le attività delle sostanze del membro di destra della reazione, come essa viene comunemente scritta, appaiono sempre al numeratore. Per i gas le unità sono sempre atmosfere, e per i soluti frazioni di moli o moli per 1000 g di acqua. Per la costante K così definita, $\Delta F^0 = -RT \ln K$.

In alcuni casi è fatto uso di funzioni di equilibrio (K_m) nelle quali invece dell'attività si impiega la molarità delle sostanze o dei ioni, in altri casi (K_c) nelle quali le concentrazioni (moli per litro) delle sostanze in soluzioni sono impiegate invece dell'attività. In altri casi sono state impiegate speciali funzioni (K'_m, o K'_c) nelle quali le attività sono usate per tutte le sostanze tranne che per gli ioni presenti. La concentrazione di un gas non viene mai impiegata in queste espressioni. *Vedi* Lewis e Randall (**885**), Randall e Vietti (**1192**), Randall (**1170.5**).

COEFFICIENTI DI ATTIVITÀ

Nel caso delle reazioni che implicano solo gli ioni del membro di destra dell'equazione, e in pochi altri casi, i vari equilibri vengono trasformati in modo che nelle tabelle sono riportati (log γ + una costante) e $\mu^{1/2}$. Con un semplice grafico, si potranno fare interpolazioni e confronti. Sovrapponendo le curve così ottenute ad altre corrispondenti (di sali di riferimento opportunamente scelti, e disegnate sulla stessa scala) si può facilmente fare l'estrapolazione rispetto al coefficiente di attività unitaria. Quando si abbiano questi valori estrapolati si può trovare il coefficiente di attività di questa particolare coppia di ioni sottraendo log *p.f.* (dato in pochi casi) dal valore di (log γ + una costante). Il coefficiente di attività per concentrazione, la forza ionica per concentrazione, ecc., sono definite nel senso in cui sono state impiegate da Randall e Vietti (**1192**), cioè il prodotto del coefficiente d'attività per concentrazione moltiplicato per la concentrazione dà l'attività (definita riferendosi alle molarità).

$$\log \gamma + \text{const.} = \log \gamma - E^0/(0{,}00019844\nu T/N) = -E/(0{,}00019844\nu\ T/N) + \log (1/m_\pm) \qquad (4)$$

dove E^0 e E sono le forze elettromotrici standard e misurate, N il numero degli equivalenti e $m_\pm$ la molarità media degli ioni studiati nella cella.* Oppure

$$\log \gamma + \text{const.} = (1/\nu) \log p + \log (1/m_\pm) \qquad (5)$$

dove p è la tensione di vapore del soluto. Oppure

$$\log \gamma + \text{const.} = (1/\nu) \log x_2 + \log (1/m_\pm)$$

dove x_2 è la frazione molare del soluto in un secondo solvente immiscibile. Oppure

$$\log \gamma + \text{const.} = \log (1/m_\pm)$$

dove $m_\pm$ è la molarità media degli ioni in equilibrio con li solido puro (solubilità). Oppure

$$\log \gamma + \text{const.} = (1/\nu) \log (1/K'_m),$$

dove K'_m è una funzione d'equilibrio nella quale si sono sostituite le attività per tutte le sostanze che prendono parte alla reazione (generalmente sostanze indissociabili o gas) eccettuata la coppia di ioni presa in considerazione. (*Vedi* $CaCO_3$ (calcite) + H_2CO_3 (aq) = Ca^{++} + $2HCO_3^-$, p. 296.)

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* In generale $\Delta F = NEF$.

A, Argon

$A.5\frac{1}{2}H_2O(?) = A(g) + 5\frac{1}{2}H_2O(l)$ (436) (E)

T	233.9	273.3	281.1	ΔH
P_A	(1) (extrap.)	98.5	210	14 885

Kr, Krypton

$Kr.5H_2O(?) = Kr(g) + 5H_2O(l)$ (436) (E)

$\Delta H = 14\ 710$

T	P	T	P
248.3	(1.0) (extrap.)	279.1	26.00
273.1	14.50	281.1	30.91
275.1	17.78	283.1	37.58
277.1	21.38	285.1*	45.19

* Critical decomposition point, T = 285.6 to 286.1°K.

O, Oxygen

$O(g)$; $C_p = 5.0$

$O_2^+(g) = O^+(g) + O$ (excited)

$\Delta H = 150\ 000$, band spectra (110); *cf.* Vol. V, p. 418

$O_2(g)$

$\Delta H^0 = 0$; $\Delta F^0 = 0$ (877, 885); $C_p = 6.5 + 0.0010T$ (876, 885)

$O_2(g) = O(g) + O$ (excited)

$\Delta H = 162\ 000$, band spectra (110); $= 150\ 000$, positive ray analysis (637, 638); *cf.* Vol. V, p. 418

$O_2(aq)$

$\Delta F^0_{298.1} = 3904$, from solubility in water (468); for activity coefficient in aqueous salt solutions, *v.* (1175)

$O_3(g)$

$C_p = 7.0 + 0.0071T - 0.00000186T^2$ (877, 885)

$\frac{3}{2}O_2(g) = O_3(g)$

$\Delta H = 34\ 600 - 2.75T + 0.028T^2 - 0.00000062T^3$ (885); $\Delta F^0 = 34\ 600 + 2.75T \ln T - 0.0028T^2 + 0.00000031T^3 - 22.4T$ (425, 885, 922, 923); *cf.* (400, 943, 1228, 1503, 1504); $\Delta F^0_{298.1} = 32\ 400$

H, Hydrogen

$H(g)$

$C_p = 5.0$; $\Delta F^0_{298.1} = 45\ 730$ (885); *see* $H_2 = 2H$

H^+

ΔF^0, ΔH^0 and all partial molal quantities are arbitrarily taken equal to 0

$H_2(g)$

$\Delta F^0 = 0$; $\Delta H^0 = 0$ (877, 885); $C_p = 6.5 + 0.0009T$ (876, 885)

$H_2(g) = 2H(g)$

$\Delta F^0 = 97\ 000 - 3.5T \ln T + 0.00045T^2 + 1.17T$; $\Delta F^0_{298.1} = 91\ 460$ (825, 826, 827, 829, 885); *cf.* (309, 1545, 1546, 1547) and Vol. V, p. 418

$H_2^+(g)$; *v.* Vol. V, p. 418

$H_2(aq)$

$\Delta F^0_{298.1} = 4182$, from solubility in water (468); for activity coefficient in aqueous salt solutions, *v.* (1175)

OH^-

$\Delta F^0_{298.1} = -37\ 455$ (885)

$(Pt)OH^-, O_2$

$E^0_{298.1} = -0.3976$ (885); $[OH^- = \frac{1}{4}O_2(g) + \frac{1}{2}H_2O(l) + E^-$; $\Delta F^0_{298.1} = 9175]$

$(Pt)H_2, OH^-$

$E^0_{298.1} = 0.8280$ (877, 885); $[\frac{1}{2}H_2(g) + OH^- = H_2O(l) + E^-$; $\Delta F^0_{298.1} = -19\ 105]$

HO_2^-; $\Delta F^0_{298.1} = -15\ 610$ (885)

$H_2O(g)$

$C_p = 8.81 - 0.0019T + 0.00000222T^2$ (885); *see* $H_2(g) + \frac{1}{2}O_2(g) = H_2O(g)$

$H_2O(g)$ (1190) *from* (56)

Activity function of water vapor in mixtures with hydrogen and with nitrogen at 323.1°K

P (atm.)	x_2 in H_2	k_2 in H_2	k_2/P in H_2	x_2 in N_2	k_2 in N_2	k_2/P in N_2
100	0.1391	93.8	0.938	0.1576	82.8	0.828
200	.0785	178.0	.890	.1001	139.6	.698
300	.0582	257.1	.857	.0796	188.0	.627
400	.0473	338.7	.847	.0684	234.1	.585
500	.0408	420.0	.840	.0623	275.0	.550
600	.0364	504.0	.840	.0584	318.0	.530
700	.0334	586.5	.838	.0551	355.6	.508
800	.0312	671.5	.839	.0527	397.4	.497
900	.0294	761.0	.845	.0505	443.0	.492
1000	.0282	849.0	.849	.0486	493.0	.493

Activity function of water vapor in mixtures with 3:1 hydrogen-nitrogen at 298.1, 310.6 and 323.1°K

P	298.1°K			310.6°K			323.1°K		
(atm.)	x_2	k_2	k_2/P	x_2	k_2	k_2/P	x_2	k_2	k_2/P
100	0.0385	87.3	0.873	0.0768	89.0	0.890	0.1451	89.9	0.899
200	.0234	154.7	.773	.0449	163.3	.817	.0846	165.0	.825
300	.0183	212.5	.708	.0341	230.9	.770	.0631	237.1	.790
400	.0157	266.8	.667	.0287	294.1	.735	.0521	307.2	.768
500	.0140	321.5	.643	.0254	377.0	.724	.0460	372.5	.745
600	.0128	377.8	.630	.0231	420.0	.700	.0417	439.5	.732
700	.0120	433.0	.619	.0214	487.0	.696	.0386	508.0	.726
800	.0113	494.5	.618	.0200	558.0	.697	.0362	579.0	.724
900	.0108	556.0	.618	.0189	632.0	.702	.0344	651.0	.723
1000	.0104	620.0	.620	.0181	702.0	.702	.0328	729.0	.729

$H_2(g) + \frac{1}{2}O_2(g) = H_2O(g)$ (116, 117, 118, 821, 914, 915, 1057, 1350, 1495, 1496); *cf.* (546, 548, 643, 1053, 1320)

$\Delta H_{298.1} = 57\ 820$; $\Delta F^0_{298.1} = -54\ 507$; $\Delta F^0 = -57\ 410 + 0.94T \ln T + 0.00165T^2 - 0.00000037T^3 + 3.92T$ (885)

T	% dissoc.	log K	I	Mean I	Lit.
1 397	0.0078	6.312	3.81	3.81	(1057)
1 480	.0184	5.753	3.94		
1 561	.0340	5.354	3.67		
1 705	.0326	4.362		3.71	(914, 915)
1 783	.0778	4.260			
1 863	.211	3.826			
1 968	.373	3.579			
2 155	1.18	3.039	3.67	3.62	(1495, 1496)
2 257	1.77	2.771	3.57		
1 325	0.00325	6.884		3.55	(821)
1 354	.0049	6.616			
1 393	.0069	6.393			
1 433	.0103	6.129			
1 455	.0142	5.922			
1 474	.0141	5.927			
1 531	.0255	5.540			
1 550	.0287	5.464			

T	% dissoc.	log K	Lit.	T	% dissoc.	log K	Lit.
2 642	4.3	2.188	(116, 117, 118)	2 337	2.8	2.470	(1350)
2 698	7.5	1.813		2 505	4.5	2.105	
2 761	6.6	1.898		2 684	6.2	1.945	
2 834	9.8	1.626		2 731	8.2	1.755	
2 929	11.1	1.554		3 092	13.0	1.430	

H_2O(l) (885); *C_p from* (48)

$\Delta H_{273.1} = -68\ 470$; $\Delta H_{291.1} = -68\ 330$; $\Delta H_{298.1} = -68\ 270$; $\Delta F^0_{298.1} = -56\ 560$; $\Delta F^0 = -70\ 650 - 8.0T \ln T + 92.84T$

t, °C	Sp. heat	C_p	t, °C	Sp. heat	C_p
0	1.0092	18.182	50	0.9978	17.98
5	1.0051	18.108	60	0.9989	18.00
10	1.0021	18.054	70	1.000	18.02
15	1.0001	18.018	80	1.002	18.05
20	0.9988	17.994	90	1.004	18.09
25	.9979	17.978	100	1.006	18.12
30	.9974	17.969	125	1.012	18.23
35	.9972	17.966	150	1.019	18.36
40	.9972	17.966	200	1.026	18.48

Fugacity of liquid water at various temperatures and pressures (1190)

P (atm.)	a (298.1°)	a (310.6°)	a (323.1°)	f (298.1°)	f (310.6°)	f (323.1°)
1	1	1	1	0.03125	0.06372	0.1219
100	1.0757	1.0728	1.0703	.03362	.06836	.13047
200	1.1576	1.1515	1.1461	.03618	.07337	.13971
300	1.2454	1.2356	1.2270	.03892	.07873	.14957
400	1.3394	1.3254	1.3132	.04186	.08445	.16009
500	1.4402	1.4214	1.4050	.04501	.09057	.17127
600	1.5481	1.5240	1.5029	.04838	.09711	.18320
700	1.6637	1.6336	1.6072	.05199	.10409	.19592
800	1.7874	1.7506	1.7184	.05586	.11155	.20947
900	1.9200	1.8755	1.8367	.06000	.11951	.22389
1000	2.0618	2.0089	1.9628	.06443	.12801	.23927

H_2O(l) = $H^+ + OH^-$

$K_{298.1} = 1.005 \times 10^{-14}$ (885); *from* (877, 911); $\Delta H = 29\ 210 - 53T$, or $\Delta C_p = -53$; $\Delta H_{291.1} = 13\ 780$ (1544.5); $\Delta F^0 = 29\ 210 + 53T \ln T - 335.86T$; $K_{273.1} = 0.114 \times 10^{-14}$; $K_{291.1} = 0.58 \times 10^{-14}$ (885); *see further* Vol. VI, p. 152 and Vol. V, p. 212

H_2O(l) = H_2O(g)

$\Delta F^0_{298.1} = 2\ 053$ (885) *from* (1301); $P_{298.1} = 23.8$ mm; *see also* (337); $\Delta H_{373.1} = 9\ 730$; $\Delta H_{298.1} = 10\ 450$ (885) *from* (1222, 1368); *see further* Vol. V, p. 138

H_2O(s); $\Delta F^0_{298.1} = -56\ 418$ (885)

H_2O(l) = H_2O(s)

$\Delta C_p = -9.11 - 0.0336\,(273.1 - T)$; $\Delta H_{273.1} = -1438$ (885, 1262) *from* (858, 1367); *see further* Vol. V, p. 95, 131

H_2O_2(g)

$C_p = 7.5 + 0.0042T$ (877, 885); $\Delta F^0 = -31\ 200 + 5.5T \ln T - 0.00115T^2 - 9.3T$; $\Delta F^0_{298.1} = -24\ 730$ (877, 885)

H_2O_2(l)

$C_p = 19.7$ (926); $\Delta F^0_{298.1} = -28\ 230$ (877, 885)

H_2O_2(l) = H_2O_2(g) (214, 1549)

$\Delta H_{347} = 12\ 300$; $\Delta F^0_{298.1} = 3\ 500$ (885)

T	P	T	P
342.1	0.038	417.1*	1.000
358.1	.086		

* Extrapolated (885).

H_2O_2(s)

$C_p = 16.0$ (926); $\Delta F^0_{298.1} = -27\ 980$ (885)

H_2O_2(l) = H_2O_2(s)

$\Delta H_{271.4} = -2\ 516$ (926); *cf.* Vol. V, p. 131; $\Delta F^0 = -1\ 512 + 3.7T \ln T - 15.16T$; $\Delta F^0_{298.1} = 252$; $\Delta H^0_{298.1} = -2\ 615$ (885)

H_2O_2(aq); $\Delta F^0_{298.1} = -31\ 470$ (885)

H_2O_2(aq) = $H^+ + HO_2^-$

$K_{273.1} = 0.67 \times 10^{-12}$; $K_{298.1} = 2.4 \times 10^{-12}$ (743); $\Delta F^0_{298.1} = 15\ 860$ (885)

H_2O_2(aq) = H_2O_2(l)

$\Delta F^0_{298.1} = 3\ 240$ (885) *from* (926)

F, Fluorine

F_2(g)

$\Delta H^0 = 0$; $\Delta F^0 = 0$; $C_p = 6.5 + 0.0011T$ (885)

HF(g); $C_p = 6.5 + 0.001T$

½H_2(g) + ½F_2(g) = HF(g)

$\Delta F^0 = -32\ 240 + 2.41T$; $\Delta F^0_{298.1} = -31\ 800$ (1018); $\Delta S^0_{298.1} = 2.41$ (833)

T	E (volts)	log P	ΔF^0
496	1.505	−1.261	−31 800
497	1.479	−1.277	−31 200
497	1.484	−1.277	−31 300
497	1.486	−1.277	−31 300
504	1.489	−1.217	−31 500
508	1.477	−1.217	−31 200
518	1.480	−1.101	−31 000
519	1.466	−1.097	−31 200
521	1.467	−1.081	−31 100
521	1.468	−1.081	−31 100
521	1.467	−1.081	−31 100
534	1.456	−0.981	−31 100
534	1.460	−0.981	−31 200
538	1.452	−0.953	−31 000
538	1.448	−0.953	−30 900
545	1.445	−0.901	−31 000
545	1.441	−0.901	−30 950

HF(l) = HF(g)

Mol. wt. of HF(l) (1352); vapor pressure, 192 to 320°K (1351)

T	P	w*
234	0.0739	87.4
252	.1895	81.6
263	.3079	74.3
273	.4789	67.6
278.3	.5737	69.3
281.6	.6461	64.3
285.0	.7579	69.5
289.0	.8697	47.7
298.1	1.186	

* w = apparent Mol. wt.

HF(aq) = $H^+ + F^-$ (1136)

$K_{298.1} = 7.2 \times 10^{-4}$ (conductivity); $\Delta F^0_{298.1} = 4300$

HF_2^- = HF(aq) + F^- (1136)

$K_{298.1} = 0.182$; $\Delta F^0_{298.1} = 1000$

$(HF)_6$(g); $\Delta F^0_{298.1} = -210\ 000$ (1018)

6HF(g) = $(HF)_6$(g)

$\Delta H_{298.1} = -40\ 000$; $\Delta F^0_{298.1} = -19\ 200$ (1352) *from* (1441)

Cl, Chlorine

Cl(g); $C_p = 5.0$ (885); *see* ½Cl_2(g) = Cl(g)

Cl^-

$\Delta F^0_{298.1} = -31\ 367$ (885), revised value − 31 345 (1195)

Cl_2(g) ($a = 1$)

ΔF^0, $\Delta H^0 = 0$; $C_p = 7.4 + 0.001T$ (885); *cf.* (1546)

½Cl_2(g) = Cl(g)

$\Delta F^0 = 35\ 000 - 1.3T \ln T + 0.00025T^2 - 1.5T$; $\Delta F^0_{298.1} = 32\ 400$ (885) *from* (1137); *cf.* (600, 601, 1138, 1450, 1452, 1505, 1546)

$Cl_2(g), Cl^-, (Pt); \frac{1}{2}Cl_2(g) + E^- = Cl^-$

$E^0_{298.1} = 1.3594$ (885); $= 1.3583$ (1195)

$Cl_2(g, a = 1) = Cl_2(g, \text{actual})$

When $P = 1$, $\Delta F^0_{298.1} = -6.5$ (885)

$Cl_2(l)$; $\Delta F^0_{298.1} = 1\ 146$

$Cl_2(g) = Cl_2(l)$

$P_{298.1} = 7.63$ atm., $a(g) = 6.99$ atm., $a(l) = 1.012$; $\Delta F^0_{298.1} = 1\ 146$ (885) *from* (766); *cf.* (603, 715, 1127, 1451)

$Cl_2(aq)$; $\Delta F^0_{298.1} = 1\ 650$ (885)

$Cl_2(g) = Cl_2(aq)$

At $P = 1$, $m(Cl_2)$ as such is 0.0618 (692); $\Delta F^0_{298.1} = 1\ 650$ (885)

Cl_2 (in CCl_4)

$\Delta F^0_{298.1} = 1\ 030$ (885)

$Cl_2(aq) = Cl_2$ (in CCl_4); *see* Vol. III, p. 419

$\Delta F^0_{298.1} = -620$ (885)

$Cl_2.8H_2O(s) = Cl_2(g) + 8H_2O(l)$ (1245) (E)

T	P	T	P
270.1	0.241	279.1	0.653
271.1	0.263	281.1	0.816
272.1	0.293	282.1	0.922
272.86	0.321	283.1	1.048
273.1	0.331	285.1	1.301
275.1	0.421	287.1	1.632
277.1	0.524	289.1	2.003

$Cl_2.8H_2O(s) = Cl_2(g) + 8H_2O(s)$ (1245) (E)

T	P	T	P
263.1	0.205	270.1	0.280
265.1	0.222	271.1	0.293
267.1	0.243	272.1	0.308
269.1	0.267	272.86	0.321*

* Quadruple point, hydrate, ice, saturated solution, vapor. For the quadruple point, hydrate, solution of H_2O in Cl_2, solution of Cl_2 in H_2O, vapor, Roozeboom (1245) finds $T = 301.8$, in good agreement with Isambert (668).

$3Cl_2(g) = 2Cl_3(g)$ (1545–1547)

ClO^-; $\Delta F^0_{298.1} = -6\ 500$ (885)

ClO_3^-; $\Delta F^0_{298.1} = -250$ (885)

$Cl_2(aq) + 3H_2O(l) = 6H^+ + 5Cl^- + ClO_3^-$

$K_{364.1} = 4.3 \times 10^{-7}$ (1100.5); $\Delta F^0_{298.1} = 7\ 650$ (885)

HCl(g)

$C_p = 6.5 + 0.0010T$ (885); $\Delta F^0 = -21\ 870 + 0.45T \ln T - 0.000025T^2 - 5.31T$; $\Delta H_{291.1} = -22\ 000$; $\Delta F^0_{298.1} = -22\ 692$ (885); $\Delta F^0_{298.1} = -22\ 741$, revised value (1195)

$\frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g) = HCl(g)$

1810°K, degree of dissociation, 0.27% (914, 915); *cf.* (1546, 1547)

$\frac{1}{2}Cl_2(g) + \frac{1}{2}H_2O(g) = HCl(g) + \frac{1}{4}O_2(g)$; *cf.* (408.2, 408.3, 1062)

$\Delta F^0 = 6\,835 - 0.02T \ln T - 0.00085T^2 + 0.000000185T^3 - 7.27T$; $\Delta F^0_{298.1} = 4\ 560$ (885)

T	log K	I	Lit.
625	−0.608	−7.56	(855)
659	−0.475	−7.59	
692	−0.380	−7.51	
723	−0.353	−7.20	(408.1)
873	−0.001	−7.09	
923	+0.100	−7.11	
703	−0.403	−7.24	(920)
753	−0.335	−6.88	

HCl(aq)

$\Delta F^0_{298.1} = -31\ 367$ (885), revised value, $-31\ 345$ (1195)

Log of activity coefficient of hydrochloric acid to 1M (1195)

m	log γ (298.1°)	a_1 (298.1°)
0.001	−0.0153	0.999965
.002	− .0211	.999928
.005	− .0322	.999825
.01	− .0438	.999650
.02	− .0585	.999310
.05	− .0812	.998295
.1	− .0993	.99660
.2	− .1156	.99321
.3	− .1213	.98975
.4	− .1227	.98623
.5	− .1210	.98262
.6	− .1171	.97891
.7	− .1118	.97509
.8	− .1058	.97124
.9	− .0987	.96726
1.0	− .0915	.96324

Log of activity coefficient of hydrochloric acid at 298.1°K in concentrated solution (1195)

m	log γ (298.1°)	a_1 (298.1°)	m	log γ (298.1°)	a_1 (298.1°)
1.2	−0.0743	0.95482	5	0.3757	0.73890
1.4	− .0556	.94605	6	.5078	.67106
1.6	− .0359	.93696	7	.6403	.6027
1.8	− .0153	.92753	8	.7705	.5361
2.0	+ .0080	.91750	9	.9000	.4720
2.5	.0610	.89224	10	1.0189	.4146
3.0	.1205	.86452	12	1.2367	.3162
3.5	.1818	.83515	14	1.4368	.2371
4	.2460	.80401	16	1.6276	.1740

Partial molal heat capacities and specific heats of aqueous hydrochloric acid at 298.1°K (1187)

m	$\bar{C}_{p1}$	$\bar{C}_{p2}$	Sp. heat
0.00	17.977	−41	0.9979
.05	17.976	−37.8	.9939
.1	17.974	−36.5	.9903
.2	17.969	−34.6	.9830
.5	17.947	−31.0	.9631
1.0	17.893	−27.0	.932

Activity coefficient in aqueous salt solutions

Salt.	$LaCl_3$	$BaCl_2$	LiCl	NaCl
Lit.	(1172)	(1172)	(527, 578, 580)	(527, 578, 580)

Salt.	KCl	CsCl
Lit.	(279, 527, 577, 578, 580, 908)	(527)

$HCl(aq) = H^+ + Cl^-$; $\Delta F^0 = 0$

$HCl.2H_2O(s) = HCl(g) + 2H_2O(s)$ (1244) (E)

T	P	T	P
249.7	0.255	254.5	0.896
251.3	0.361	254.9	1.039
252.6	0.495	255.05	1.175
253.05	0.551	255.27	1.302
253.9	0.703	255.4*	1.421
254.3	0.826		

* Melts at atm. pressure.

$HClO(aq)$; $\Delta F^0_{298.1} = -19\ 018$ (885)

$HClO(aq) = H^+ + ClO^-$

$K_{298.1} = 6.7 \times 10^{-10}$ (1091); $\Delta F^0_{298.1} = 12\ 520$ (885); *cf.* (1292, 1392)

$Cl_2(aq) + H_2O(l) = H^+ + Cl^- + HClO$ (516, 692)
$\Delta F^0_{298.1} = 4\ 525$ (885); *cf.* (516, 692)

T	$K \times 10^4$	T	$K \times 10^4$
273.1	1.45	303.1	5.65
278.1	1.96	303.1*	6.24
283.1	2.58	308.1	6.43
288.1	3.28	313.1	7.15
288.1*	3.22	318.1	7.84
293.1	4.06	323.1	8.51
298.1	4.84	328.1	9.12
298.1*	4.66	333.1	9.75

* From (516) recalculated by (692); all other values from (692).

$HClO_3(aq)$; $\Delta F^0_{298.1} = -250$ (885)

Br, Bromine

$Br(g)$; $C_p = 5.0$; $\Delta F^0_{298.1} = 18\ 250$ (885)

Br^-; $Br_2(l)$, Br^-, Pt
$\Delta F^0_{298.1} = -24\ 595$ (885), revised value, $-24\ 574$; $E^0_{298.1} = 1.0659$(885), revised value, 1.0650

$Br_2(g)$
$C_p = 7.4 + 0.001T$; $\Delta F^0_{298.1} = 755$ (885); *see* $Br_2(l) = Br_2(g)$

$Br_2(g) = 2Br(g)$
$\Delta F^0 = 41\ 600 - 2.6T \ln T + 0.0005T^2 - 5.0T$; $\Delta F^0_{298.1} = 35\ 740$ (885) *from* (1128) and entropies

T	log K	ΔH	Lit.*
923	−5.983		(334)
1 000	−5.267		
1 051	−4.944	41 200	
1 073	−3.747		(1128)
1 075.7	−3.775		(131)
1 123	−3.395		(1128)
1 130	−4.296		(334)
1 173	−2.854	42 100	(1128)
1 173	−3.982		(334)
1 176.7	−3.119		(131)
1 223	−2.484	41 900	(1128)
1 273	−2.114	41 500	
1 275.6	−2.376		(131)
1 299.1	−2.222		
1 323	−1.740	41 000	(1128)
1 326.1	−2.093		(131)
1 333.8	−1.999		
1 352.4	−1.871		
1 396.6	−1.623		
1 408.6	−1.585		
1 443.2	−1.408		
1 477.9	−1.244		
1 483.4	−1.209		
1 555.8	−0.885		
1 557.8	−0.876		

* *See also* (166, 600, 601, 603, 675, 1545–1547).

$Br_2(l)$; ΔH^0, $\Delta F^0 = 0$; $C_p = 17.0 + 0.001T$ (885)

$Br_2(l) = Br_2(g)$
$\Delta F^0 = 10\ 450 + 9.6T \ln T - 87.21T$; $\Delta H_{305.1} = 7\ 520$; $\Delta F^0_{298.1} = 755$ (885) *from* (1169, 1243); *cf.* Vol. V, p. 135

$Br_2(s)$
$C_p = 17.0 + 0.001T$; $\Delta F^0_{298.1} = 314$ (885)

$Br_2(l) = Br_2(s)$
$\Delta F^0 = -2580 + 9.71T$; $\Delta H = -2580$; $\Delta F^0_{298.1} = 314$ (885); *cf.* Vol. V, p. 131

$Br_2(aq)$
$\Delta F^0_{298.1} = 977$ (885); in satd. soln. at 298.1°, $m = 0.207$, $\gamma = a_2/m = 0.925$ *from* (172)

$Br_2(l) = Br_2(aq)$
$\Delta F^0_{298.1} = 977$ (885) *from* (690, 890); at 298.1°, $m = 0.207$ (172)

Br_2 (in CCl_4)
$\Delta F^0_{298.1} = 389$ (885)

Br_2 (in CCl_4) $= Br_2(g)$
at 298.1°, $P_2/x_2 = 0.539$ (890); $\Delta F^0_{298.1} = 366$ (885)

Br_2 (in CCl_4) $= Br_2(aq)$

x_2	0.14	0.0	$\Delta F^0_{298.1}$
m/x_2	0.35	0.371	588
Lit.	(690)	(890)	(885)

$Br_2.10H_2O(s) = Br_2(g) + 10H_2O(s)$ (1251) (E)

T	P	p_{H_2O}	p_{Br_2}
263.1	0.033	0.00262	0.030
265.1	.037	.00313	.0337
267.1	.041	.00371	.0371
269.1	046	.00439	.0417
271.1	.051	00516	.0461
272.1	.054		
272.8	.057*		

* Quadruple point for solid bromohydrate, ice, satd. soln., vapor.

$Br_2.10H_2O(s) = Br_2(g) + 10H_2O(l)$ (1251) (E)

T	p_{Br_2}	T	p_{Br_2}
273.5	0.0664	278.1	0.106
275.1	.075	278.6	.112
276.1	.0836	279.0	.118
277.2	.096	279.3	.122*

* Quadruple point for solid bromohydrate, liq. H_2O, liq. Br_2, vapor. According to (1472, 1473) at the quadruple point the pressure is 1 atm. at $T = 279.9°$; in oxygen, 150 atm. at $T = 293.1°$.

$3Br_2(g) = 2Br_3(g)$ (1545–1547)

Br_3^-; $\Delta F^0_{298.1} = -25\ 230$ (885)

$Br^- + Br_2(aq) = Br_3^-$; *cf.* (221, 691, 725, 729, 899, 1121, 1466)
$\Delta F^0_{298.1} = -1\ 610$ (885); $K_{298.1} = 15.2$ (890)

$Br_3^- + Br_2(aq) = Br_5^-$ (729, 899)

BrO_3^-; $\Delta F^0_{298.1} = 2\ 300$ (885)

$\frac{1}{2}Br_2(l) + 3H_2O(l) = 6H^+ + BrO_3^- + 5E^-$
$\Delta F^0_{298.1} = 172\ 000$ (885) *from* (1291)

$HBr(g)$
$C_p = 6.5 + 0.001T$; $\Delta F^0_{298.1} = -12\ 540$ (885); *see* $\frac{1}{2}H_2(g) + \frac{1}{2}Br_2(g) = HBr(g)$

$\frac{1}{2}H_2(g) + \frac{1}{2}Br_2(g) = HBr(g)$
$\Delta F^0 = -11\ 970 + 0.45T \ln T - 0.000025T^2 - 5.74T$; $\Delta F^0_{298.1} = -12\ 920$ (885); *cf.* (401); $E^0_{303.1} = 0.557$, 0.558 and 0.549, or $\Delta F^0_{303.1} = -12\ 800$ (133)

T (408.2)	log K	I
1 297.1	2.60	−5.87
1 381.1	2.44	−5.72
1 495.1	2.27	−5.64

$HBr(aq)$; $\Delta F^0_{298.1} = -24\ 595$ (885), revised value, $-24\ 574$

m	6.0	7.0	8.0	9.0	10.0	11.0
γ	6.14	8.23	11.2	15.8	23.0	33.4

In C_2H_5OH (1331); in NaBr(aq) and KBr(aq) (1153).

$HBr(aq) = HBr(g)$ (60); *cf.* (1482.1, 1482.2)
At 298.1°

m	$P \times 10^4$	m	$P \times 10^4$
6	0.01987	9	0.2974
7	0.04868	10	0.7763
8	0.1171	11	1.987

$\frac{1}{2}H_2(g) + \frac{1}{2}Br_2(aq) = HBr(aq)$ *from* (890)

log $[H^+]$	log $[Br^-]$	log $[Br_2(aq.)]$	$E_{298.1}$	log γ + const.*	$\mu^{1/2}$
−2.0000	−2.0334	−2.3062	1.2623	−9.2302	0.1000
−2.0000	−2.0123	−2.7416	1.2476	−9.2254	.1000
−2.0000	−2.0092	−2.8671	1.2442	−9.2295	.1000
−1.5229	−1.5591	−2.2716	1.2093	−9.2492	.1732
−1.5229	−1.5391	−2.6273	1.1976	−9.2492	.1732
−1.5229	−1.5302	−3.0259	1.1852	−9.2485	.1732
−1.0000	−1.0825	−1.8891	1.1648	−9.2772	.3162
−1.0000	−1.0635	−2.0123	1.1600	−9.2769	.3162
−1.0000	−1.0283	−2.3778	1.1471	−9.2768	.3162
−1.0000	−1.0092	−2.8827	1.1312	−9.2782	.3162

* Constant = −9.1883.

$HBr.H_2O(s) = HBr(g) + zH_2O(g) + H_2O.xHBr(l)$ (1248–1250) (E)

T	P	T	P
257.5	2.5	265.9	6.0
258.3	2.75	267.3	7.0
259.1	3.0	268.4	8.0
262.1	4.0	269.1	9.0
264.4	5.0	269.8	10.5*

* Appearance of liquid HBr.

$2(HBr.H_2O)(s) = HBr.2H_2O(s) + HBr(g)$ (1248–1250) (E)

T	P	T	P
244.6	0.100	253.1	0.172
247.1	.112	255.1	.205
249.1	.126	257.1	.242
251.1	.146	257.6	.257*

* Appearance of solution of HBr in H_2O.

$HBr.2H_2O(s) = HBr(g) + zH_2O(g) + H_2O.xHBr(l)$ (1248–1250) (E)

T	P	T	P
The solution contains less HBr than the hydrate			
248.1	0.0013	260.1	0.289
251.3	.013	260.7	.368
254.2	.039	261.1	.447
256.3	.079	261.5	.579
258.5	.158	261.8	.691*
The solution contains more HBr than the hydrate			
257.6	2.5	260.5	1.5
258.3	2.25	261.1	1.25
259.1	2.00	261.5	1.00
259.8	1.75		

* M. P.; hydrate and solution contain equal amounts of HBr.

$HBrO(aq)$; $\Delta F^0_{298.1} = -19\ 680$ (885)

$Br_2(aq) + H_2O(l) = H^+ + Br^- + HBrO(aq)$; *cf.* (171, 1121)

$\Delta F^0_{298.1} = 11\ 310$ (885); $K_{298.1} = 5.2 \times 10^{-9}$ (172); $K_{273.1} = 5.7 \times 10^{-10}$ (729)

$HBrO_3(aq)$; $\Delta F^0_{298.1} = 2\ 300$ (885)

I, Iodine

$I(g)$

$C_p = 5$; $\Delta F^0_{298.1} = 15\ 470$ (885)

I^-; $I_2(s)$, I^-, Pt

$E^0_{298.1} = 0.5357$ (885), revised value, 0.5345 (1181); $\Delta F^0_{298.1} = -12\ 361$ (885), revised value, $-12\ 333$ (1181)

$I_2(g)$

$C_p = 7.4 + 0.001T$; $\Delta F^0_{298.1} = 4\ 630$ (885)

$I_2(g) = 2I(g)$

$\Delta F^0 = 31\ 700 - 2.6T \ln T + 0.0005T^2 - 3.4T$; $\Delta F^0_{298.1} = 26\ 310$ (885) *from* (1399); *cf.* (169, 341, 483, 529, 1403)

$I_2(l)$

$\Delta F^0 = 4\ 000 - 10.34T$; $\Delta F^0_{298.1} = 920$ (885)

$I_2(s)$

ΔF^0, $\Delta H^0 = 0$ (885)

$I_2(s) = I_2(g)$

$\Delta F^0_{298.1} = 4\ 630$ (885) *from* (67); *cf.* (549, 1045, 1046)

$I_2(s) = I_2(l)$

$\Delta F^0 = 4\ 000 - 10.34T$; $\Delta F^0_{298.1} = 920$ (885); *cf.* (1169, 1170)

$I_2(aq)$

$\Delta F^0_{298.1} = 3\ 926$, corrected for hydrolysis, (878) *from* (173, 174, 587, 690); activity coefficient in aqueous salt solutions (1176) *from* (260)

I_2(in var. solvents) $= I_2(g)$

In $CHCl_3$, CCl_4, CS_2, $C_4H_{10}O$ (ether) and C_6H_6 (benzene) (1046)

$3I_2(g) = 2I_3(g)$ (1545–1547)

I_3^-; $\Delta F^0_{298.1} = -12\ 315$ (885)

$I_3^- = I^- + I_2(aq)$ (173, 174, 210, 322, 359, 413, 424, 605, 633, 691, 729, 730, 731, 899, 1466, 1467, 1477, 1507)

In HI(aq) at 298.1°K (1507)

$c_{(\Sigma HI)}$	$c_{(\Sigma HI_3)}$	$c_{(I_2)}$	10^3K_c
0.05715 to 0.0801	0.000904 to .0821	0.0000202 to .00132	1.30 + a.d. = 0.015

In KI(aq) at 298.1°K (885) *from* (173, 174)

μ	$[KI]/[KI_3]$	μ	$[KI]/[KI_3]$
0.001	1.14	0.010	1.06
.002	1.11	.020	1.04
.005	1.08	.100	0.99

$2I_3^- + 4I_2(s) = I_{14}^{--}$ (173, 174, 899, 1112)

IO_3^-; $\Delta F^0_{298.1} = -31\ 580$ (885)

$\frac{1}{2}I_2(s) + 3H_2O(l) = 6H^+ + IO_3^- + 5E^-$; *cf.* (10, 1357, 1358)

$E^0_{298.1} = -1.197$ (1291); $\Delta F^0_{298.1} = 138\ 100$ (885)

$HI(g)$

$C_p = 6.5 + 0.001T$; $\Delta F^0_{298.1} = 315$ (885)

$\frac{1}{2}H_2 + \frac{1}{2}I_2(g) = HI(g)$; *cf.* (287, 408, 409, 410, 820)

$\Delta F^0 = -1\ 270 + 0.45T \ln T - 0.000025T^2 - 5.01T$; $\Delta F^0_{298.1} = -2\ 000$ (885) *from* (126)

T	ln K	I
553	2.2229	−4.94
633	2.0984	−5.05
713	1.9631	−5.06
793	1.8219	−5.00
T (1401)	ΔF^0	I
304.7	−2 036	−5.0
328.3	−2 019	−4.8
354.7	−1 958	−4.5

$HI(aq)$

$\Delta F^0_{298.1} = -12\ 361$ (885); activity coefficient at 298.1°K (885)

m	6	7	8	9	10
γ	6.35	9.71	16.1	30.5	57.9

$HI(aq) = I^- + H^+$; $\Delta F^0 = 0$

$HI(aq) = HI(g)$ (60)

m	$P_{HI} \times 10^4$(298.1°K)	m	$P_{HI} \times 10^4$(298.1°K)
6	0.00750	9	0.3882
7	.02395	10	1.737
8	.08555		

HIO(aq); $\Delta F^0_{298.1} = -23\ 170$ (885)

HIO(aq) = $H^+ + IO^-$; $K = ca.\ 10^{-11}$ (460)

I_2(aq) + H_2O(l) = $H^+ + I^-$ + HIO(aq)
$K_{298.1} = 3 \times 10^{-13}$ (171, 172); *cf.* (1040, 1355, 1356); $\Delta F^0_{298.1} = 17\ 100$ (885)

$2HIO_3$(s) = I_2O_5(s) + H_2O(g) (338, 844) (E)

T	P	T	P
293.1	0.001	351.6	0.217
313.1	0.012	358.1*	0.386
342.1	0.150	373.1	0.692

* From (338); all other values from (844).

HIO_3(aq); $\Delta F^0_{298.1} = -31\ 580$ (885)

ICl_3 (493)

S, Sulfur

S(g)
$C_p = 5$; $\Delta F^0_{298.1} = 30\ 240$ (885)

S_2(g)
$C_p = 6.5 + 0.001T$ (885); $\Delta F^0_{718.1} = 3\ 320$; $\Delta F^0_{298.1} = 18\ 280$; $\Delta H_{298.1} = 29\ 690$; $\Delta F^0 = 30\ 580 + 1.74T \ln T + 0.0042T^2 - 52.4T$ (879, 885) *from* (124, 1159, 1160)

S_2(g) = 2S(g); *cf.* (117, 217)
$\Delta F^0 = 46\ 700 - 3.5T \ln T + 0.0005T^2 + 4.6T$; $\Delta F^0_{2200} = 0$ (1052); $\Delta F^0_{298.1} = 42\ 200$ (885)

S_6(g)
$\Delta F^0 = 22\ 600 - 35.9T$; $\Delta F^0_{298.1} = 11\ 900$ (885)

S_8(g)
$\Delta F^0 = 20\ 000 - 33.6T$; $\Delta F^0_{298.1} = 10\ 000$ (885)

S (rhomb) = S (equilib. vapor) and $S_{\lambda,\mu}$(l) = S (equilib. vapor); *see* Vol. III, p. 201

Pt, S^{--}, S (rhomb)
$E^0_{298.1} = 0.51$ (885)

S_λ(l)
$C_p = 5.4 + 0.005T$ (885) *from* (875); $\Delta F^0_{298.1} = 94$ (885)

S (rhomb) = S_λ(l)
$\Delta H_{373.1} = 467$ (875); M. P. = 112.8°C (779, 1373); $\Delta F^0 = -35 - 1.28T \ln T - 0.00015T^2 + 7.77T$ (885)

$S_\lambda = S_\mu$; $\Delta H = 416$ (875)

$S_{\lambda,\mu}$(l); $\Delta F^0_{298.1} = 93$ (885)

$2S_{\lambda,\mu}$(l) = S_2(g)
$\Delta F^0_{623.1} = 7\ 710$; $\Delta F^0_{718.1} = 4\ 660$; $\Delta F^0_{723.1} = 4\ 590$ (879, 885) *from* (124, 1159, 1160)

S_λ(l) = $S_{\lambda,\mu}$(l) (879, 885) *from* (259, 875, 1375); $\Delta F^0_{383.5} = -2.7$ *from* S (rhomb) = $S_{\lambda,\mu}$(l)

T	y*	$\int_{298}^{T} -\frac{416y}{T^2}dt$	ΔF^0
298	0.008	0.0	− 0.8
373	.031	−0.00465	− 2.5
393	.040	−0.00664	− 3.4
413	.055	−0.00902	− 4.5
423	.067	−0.01037	− 5.2
433	.111	−0.01217	− 6.1
443	.187	−0.01553	− 7.7
453	.225	−0.01981	− 9.8
473	.270	−0.0295	−14.8
510	.313	−0.0496	−26.1
573	.332	−0.0771	−45.0
653	.338	−0.1070	−70.9
718	.341	−0.1267	−91.8

* y = mole fraction of S_μ in $S_{\lambda,\mu}$.

$6S_{\lambda,\mu}$(l) = S_6(g)
$\Delta F^0_{718.1} = 860$ (885) *from* (1159, 1160)

$8S_{\lambda,\mu}$(l) = S_8(g)
$\Delta F^0_{718.1} = 1\ 250$ (885) *from* (1159, 1160)

S (monocl); $C_p = 3.62 + 0.0072T$ (885)

S (monocl) = S_λ(l)
$\Delta F^0_{392.1} = 0$ (1374, 1526); $\Delta F^0 = -155 - 1.78T \ln T + 0.0011T^2 + 10.60T$ (879, 885)

S (rhomb)
ΔF^0, $\Delta H^0 = 0$; $C_p = 4.12 + 0.0047T$ (885)

S (rhomb) = S (monocl) (189)
$\Delta F^0 = 120 + 0.50T \ln T - 0.00125T^2 - 2.820T$; $\Delta F^0_{298.1} = 17.5$ (879, 885); $\Delta F^0_{368.1} = 0$; $\Delta H_{273.1} = 77.0$; $\Delta F^0_{298.1} = 18.3$ (879, 885)

T	Solvent	s (rhomb)*	s (monocl)*	Ratio
273.1	Chloroform	11.01	7.88	1.40
	Ethyl bromide	8.52	6.11	1.40
	Ethyl ether	1.13	0.80	1.41
	Ethyl formate	0.28	0.19	1.4
288.6	Chloroform	16.58	12.53	1.33
291.7	Benzene	20.04	15.12	1.32
298.4	Benzene	23.35	18.35	1.27
	Ethyl alcohol	0.66	0.52	1.3
	Ethyl bromide	16.76	13.07	1.28
	Ethyl ether	2.56	2.00	1.28
313.1	Chloroform	29	0.24	1.2

* s is the solubility in grams/liter of soln.

S^{--}; $\Delta F^0_{298.1} = 23\ 450$ (885)

SO_2(g)
$C_p = 7.0 + 0.0071T - 0.00000186T^2$; $\Delta F^0_{298.1} = -69\ 660$ (885); *cf.* (886, 1052)

SO_2(aq); $\Delta F^0_{298.1} = -69\ 770$ (885)

SO_2(aq) = SO_2(g)
$\Delta F^0_{298.1} = 110$ (885) *from* (894); *cf.* (1347); in H_2SO_4 (aq) (357, 358)

$SO_2.7H_2O$(?) = SO_2(g) + $7H_2O$(s)(1246) (E)

T	P	T	P
264.1	0.197	269.1	0.2545
265.1	0.211	270.1	0.2716
267.1	0.233	270.5	0.2785*

* Quadruple point, hydrate, ice, soln., vapor.

$SO_2.7H_2O$(?) = SO_2(g) + $7H_2O$(l) (1246); *cf.* (1472, 1473) (E)

T	P	T	P
267.1	0.180	275.9	0.568
269.1	0.2321	277.55	0.683
270.1	0.264	279.1	0.876
270.5	0.2785	281.5	1.218
271.1	0.303	283.1	1.548
272.1	0.345	284.4	1.977
273.1	0.391	284.85	2.191
273.23	0.395	285.15	2.311*

* Quadruple point, hydrate, satd. soln. of SO_2 in H_2O, satd. soln. of H_2O in SO_2, vapor.

SO_3(g); $\Delta F^0_{298.1} = -85\ 890$ (885)

SO_2(g) + ½O_2(g) = SO_3(g)
$\Delta F^0 = -22\ 600 + 21.36T$; $\Delta F^0_{298.1} = -16\ 230$ (885) *from* (136)

T	log K	I	T	log K	I
801	1.496	21.35	1000	0.268	21.37
852	1.141	21.31	1062	−0.020	21.38
900	0.816	21.37	1105	−0.202	21.37
953	0.510	21.38	1170	−0.446	21.36

SO_3^{--}; $\Delta F^0_{298.1} = -116\ 680$ (885)

SO_4^{--}; $\Delta F^0_{298.1} = -176\ 500$ (885)

$\mathbf{HS^-}$; $\Delta F^0_{298.1} = 2\ 980$ (885)

$\mathbf{HS^- = H^+ + S^{--}}$

$K_{298.1} = 10^{-15}$; $\Delta F^0_{298.1} = 20\ 470$ (885) *from* (768); *cf.* (177, 699, 1506)

$\mathbf{H_2S(g)}$

$C_p = 8.81 - 0.0019T + 0.00000222T^2$; $\Delta F^0_{298.1} = -7\ 840$ (885)

$\mathbf{H_2(g) + \frac{1}{2}S_2(g) = H_2S(g)}$ (885); *cf.* (1157)

$\Delta F^0 = -19\ 200 + 0.94T \ln T + 0.00165T^2 - 0.00000037T^3 + 1.65T$; $\Delta F^0_{298.1} = -16\ 980$ (885)

T	log K	I	Lit.
1 023	2.025	1.68	(1160)
1 103	1.710	1.63	
1 218	1.305	1.64	
1 338	0.964	1.63	
1 362	.902	1.63	(1171)
1 405	.793	1.64	(1160)
1 473	.643	1.61	(1171)
1 537	.490	1.69	
1 667	.257	1.69	

$\mathbf{S\ (rhomb) + 2HI(g) = I_2(s) + H_2S(g)}$ (885) *from* (1150)

$\Delta F^0 = -17\ 880 - 4.89T \ln T + 0.0043T^2 - 0.00000037T^3 + 58.31T$; $\Delta F^0_{298.1} = -8\ 470$

T	log K	I
313.2	5.595	58.27
323.2	5.223	58.32
333.2	4.878	58.33

$\mathbf{3H_2(g) + SO_2(g) = H_2S(g) + 2H_2O(g)}$ (885, 1171)

$\Delta F^0 = -50\ 760 + 0.07T \ln T + 0.00775T^2 - 0.00000142T^3 + 9.35T$

T	log $K_{\text{cor.}}$*	I
1 160	5.93	9.03
1 362	4.33	9.02
1 473	3.57	9.27
1 473	3.50	9.59
1 645	2 53	9.85

* log K corrected for $S_2(g) = 2S$.

$\mathbf{2H_2O(g) + S_{\lambda,\mu}(l) = 2H_2S(g) + SO_2(g)}$

$K_{718.1} = 0.00154$; $\Delta F^0_{718.1} = 9\ 240$ (882)

$\mathbf{H_2S(aq)}$

$\Delta F^0_{298.1} = -6\ 490$ (885); for activity coefficient in aqueous salt solutions at 298.1°K, *v.* (977, 1175)

$\mathbf{H_2S(aq) = H^+ + HS^-}$; *cf.* (177, 699, 1506)

$K_{291.1} = 0.91 \times 10^{-7}$ (34); $K_{298.1} = 1.15 \times 10^{-7}$; $\Delta H = 6\ 000$; $\Delta F^0_{298.1} = 9\ 470$ (885)

$\mathbf{H_2S(g) = H_2S\ (aq)}$

$\Delta F^0_{298.1} = 1\ 350$ (885) *from* (754.5, 1532); $= 1\ 363$ (977)

$\mathbf{H_2S.6H_2O(s) = H_2S(g) + 6H_2O(s)}$ (1305) (E)

$\log P_{\text{mm}} = -\frac{1333}{T} + 3.8585$ (range −26 to −1°C); $\Delta H = 5\ 550$

$\mathbf{H_2S.6H_2O(s) = H_2S(g) + 6H_2O(l)}$ (434, 440, 1305); *cf.* (233) (E)

The $\frac{1}{T}$ *vs.* log P graph is linear between $P_{273.1} = 0.974$ and $P_{282.1} = 2.5$ atm. and between $P_{282.1} = 2.5$ and $P_{301.6} = 16$ atm. Critical decomposition at 29°C and 23 atm. (233); $P = 50$ atm. at 30°C; $\Delta H = 14\ 270$.

Partial pressures (interpolated)

T, °K.		274.0	275.0	276.0	277.0	278.0	280.0	282.0
$10^3P_{\text{atm.}}$	H_2O	7	7.2	7.2	7.9	8.6	9.9	11.2
	H_2S	1 092	1 221	1 329	1 485	1 611	1 971	2 408

$\mathbf{H_2SO_3(aq)}$; $\Delta F^0_{298.1} = -126\ 330$ (885)

$\mathbf{SO_2(aq) + H_2O(l) = H_2SO_3(aq)}$; $\Delta F^0 = 0$ (885)

$\mathbf{H_2SO_3(aq) = H^+ + HSO_3^-}$

$K_{298.1} = 0.017$; $\Delta F^0_{298.1} = 2\ 410$ *from* (355, 698, 778, 779, 976)

$\mathbf{HSO_3^-}$; $\Delta F^0_{298.1} = -123\ 920$ (885)

$\mathbf{HSO_3^- = H^+ + SO_3^{--}}$

$K_{298.1} = 5 \times 10^{-6}$ (698); $\Delta F^0_{298.1} = 7\ 240$ (885)

$\mathbf{HSO_4^- = H^+ + SO_4^{--}}$

$\Delta F^0 = 0$ (885); however, $K_{298.1} = 3 \times 10^2$ (1088); $= 2 \times 10^2$ (783, 784); *see also* (356, 384.5, 1444)

$\mathbf{H_2SO_4(g) = SO_3(g) + H_2O(g)}$ (134)

$\mathbf{S_\lambda(l) + 2H_2SO_4(aq) = 3SO_2(g) + 2H_2O(g)}$

$\Delta F^0 = 91\ 205 - 12.8T \ln T - 0.00625T^2 + 0.00000019T^3 + 124.6T$; $\Delta F^0_{298.1} = 31\ 500$ (88)

$\mathbf{H_2SO_4(aq)}$; $\Delta F^0_{298.1} = -176\ 500$ (885)

m	$\gamma_{298.1}$	m	$\gamma_{298.1}$
0.01	0.617	2	0.147
.02	.519	3	.166
.05	.397	4	.203
.1	.313	5	.242
.2	.244	10	.660
.5	.178	15	1.26
1	.150	20	2.22

Partial molal heat capacities at *ca.* 288°K (885) *from* (112); *cf.* (348)

x_2	$\bar{C}_{p1}$	$\bar{C}_{p2}$	x_2	$\bar{C}_{p1}$	$\bar{C}_{p2}$
0.00	18.02	10.4	0.30	13.78	34.3
.01	17.98	14.7	.35	12.02	38.1
.02	17.87	21.8	.40	10.45	40.7
.04	17.75	26.8	.50	15	35
.06	17.96	23.0	.60	21.6	29.8
.08	18.31	17.1	.70	19.7	30.6
.10	18.61	14.7	.80	16.2	31.9
.15	17.80	19.9	.90	11.7	32.7
.20	16.68	25.3	1.00	8.1	33.0
.25	15.33	30.1			

For activity coefficient in $ZnSO_4(aq)$ at 298.1°K, *v.* (30, 1184). For activity coefficient in $Na_2SO_4(aq)$ at 298.1°K, *v.* (11, 580, 583, 1184); $E^0_{298.1} = 0.6241$.

Partial molal heat content at *ca.* 298°K (885) *from* (192)

x_2	$\bar{L}_1$	$\bar{L}_2$	x_2	$\bar{L}_1$	$\bar{L}_2$
0.00	0.0	0	0.55	−5 730	19 040
.05	− 43.7	4 130	.60	−6 300	19 530
.10	− 293.3	7 730	.65	−6 690	19 740
.15	− 580	9 310	.70	−7 010	19 910
.20	−1 000	11 190	.75	−7 280	20 027
.25	−1 450	12 680	.80	−7 490	20 098
.30	−1 910	13 970	.85	−7 700	20 136
.35	−2 470	15 130	.90	−7 870	20 153
.40	−3 060	16 160	.95	−8 050	20 172
.45	−3 880	17 240	1.00	−8 220	20 200
.50	−4 850	18 310			

$\mathbf{H_2SO_4(aq) = H^+ + HSO_4^-}$; $\Delta F^0_{298.1} = 0$ (885)

$\mathbf{SO_2Cl_2(g)}$; $\Delta F^0_{298.1} = -71\ 560$ (885)

$\mathbf{SO_2(g) + Cl_2(g) = SO_2Cl_2(g)}$

$\Delta F^0 = -11\ 150 + 31T$ (range 383 to 411°K); $\Delta F^0_{298.1} = -1\ 900$ *from* (1445, 1447)

$\mathbf{SO_2(g) + Br_2(g) = SO_2Br_2(g)}$ (1447)

$\mathbf{S_2O_3^{--}}$; $\Delta F^0_{298.1} = -125\ 110$ (89)

$\mathbf{S_n^{--} + H_2S(aq) = 2SH^- + (n - 1)\ S(s)}$ (502)

With Na^+, $m = 0.0995$ to 0.303 at 298.1°K, $K(n = 2) = 17.9$ to 25.1; $K(n = 4) = 64.8$ to 85.9

Se, Selenium

Se (hexagonal); ΔF^0, $\Delta H^0 = 0$

Se (hexagonal) = Se (g, equilib.) (345)

Se(l) = Se (g, equilib.) (345, 841, 1158)

$Se_6 = 3Se_2(g)$ (1158); *cf.* (1498)
Gas assumed to obey perfect gas law

T	K	T	K
823.1	9.2×10^{-7}	973.1	2.51×10^{-4}
873.1	7.41×10^{-6}	1 023.1	1.16×10^{-4}
923.1	4.78×10^{-5}	1 073.1	4.78×10^{-3}

$HSeO_3^- = H^+ + SeO_3^{--}$; $K_{298.1} = 0.87 \times 10^{-8}$ (1529)

$2H_2Se(g) = 2H_2(g) + Se_2(g)$ (1158); *cf.* (1122)
$H_2(g)$ and $H_2Se(g)$ assumed perfect gases; P_{Se_2} calculated from K for $Se_6 = 3Se_2$

T	873.1	923.1	1023.1
K	8.4×10^{-8}	3.42×10^{-7}	1.14×10^{-6}

$H_2Se(aq) = H^+ + HSe^-$; $K_{298.1} = 1.7 \times 10^{-4}$ (215)

$H_2Se(g) = H_2Se(aq)$ (972)
$P_{H_2Se} = 1$ (972); $\Delta H_{298.1} = -2\ 431$ (437, 438); $\Delta F^0_{298.1} = 1\ 467$ (972)

T	$c_{(H_2Se,aq)}$	T	$c_{(H_2Se,aq)}$
287.7	0.09789	298.7	0.08277
288.1	.09611	308.1	.07317
298.1	.08415		

In HI(aq) at 298.1°K (972).

$H_2Se.xH_2O(?) = H_2Se(g) + xH_2O(?)$ (437, 438) (E)

T	P	T	P
273.1	0.455	281.1	1.00
275.45	.568	287.2	1.9
276.5	.645	295.1	5.0
278.5	.786	303.1*	11.0
280.6	.945	$\Delta H = 16\ 820x$	

* Critical decomposition temperature.

$H_2SeO_3(s) = SeO_2(s) + H_2O(g)$ (947, 992)

T	P	T	P
294.1	0.0013	335.1	0.0332
297.1	.0021	345.4	.0561
305.1	.0042	348.1	.0651
314.1	.0078	353.1	.0787
316.1	.0097	364.2	.1261
318.1	.0107	378.1	.1966
321.1	.0142	384.1	.2419
322.1	.0153		

$SeO_2.4HCl(s) = SeO_2(s) + 4HCl(g)$
$P = 1$ atm. at 379°K (339, 340)

$SeO_2.4HBr(s) = SeO_2(s) + 4HBr(g)$
$P = 1$ atm. at 328°K (339, 340)

$H_2Se(g) + I_2(s) = 2HI(g) + Se(amorp)$ (1240)

T	273.1	290.0	300.0	ΔH
K	33.68	22.62	18.06	3 954

$H_2SeO_3(aq) = H^+ + HSeO_3^-$
$K_{298.1} = 3.45 \times 10^{-3}$ (1259); $K_{298.1} = 4.0 \times 10^{-5}$ (1529)

Te, Tellurium

Te(s); ΔF^0, $\Delta H^0 = 0$

Te(g, equilib.) (90, 357, 1287, 1288, 1498)

$Te(s) + 2E^- = Te^{--}$; $(Te(s), Te^{--})$
$E^0_{292-293} = -0.894$ (749)

$Te(s) = Te^{++++} + 4E^-$; $(Te(s), Te^{++++})$
$E_{292-293} = -0.549$; $(Te^{++++}) = 0.25m$ (748, 749); $E^0_{292-293} = -0.558$ (1200)

$5Te = 2Te_2^{--} + Te^{++++}$
$K_{room} = 10^{-95}$ (747, 748, 749)

$TeO_2(s) + 4H^+ = Te^{++++} + 2H_2O(l)$
In HCl(aq) at 291.1°K (750)

$c_{(HCl)}$	$c_{(Te^{++++})}$	$c_{(HCl)}$*	$c_{(Te^{++++})}$*	K*
0.10	0.00057	0.22	0.000039	0.026
.22	.0012	.458	.00039	.016
.46	.0037	.73	.0029	.022
.92	.0091	.914	.0060	.021
				Mean = 0.021

* By emf method (750).

$2Te(s) + 2E^- = Te_2^{--}$; $(Te(s), Te_2^{--})$
$E_{292-293} = -0.818$; $Te_2^{--} = 0.5m$; $E^0_{292-293} = -0.836$ (748, 749); $E^0_{292-293} = -0.827$; $Te_2^{--} = 0.5m$ (1200)

$Te_2^{--} = Te^{--} + Te(s)$; $K_{292} < 10^{-2}$ (749)

$TeO_3^{--} + 3H_2O(l) = Te^{++++} + 6OH^-$
$K_{292-293} = 1.7 \times 10^{-47}$ (748, 749, 1200)

$HTeO_3^- = H^+ + TeO_3^{--}$
$K_{298.1} = 10^{-8}$ (122); $= 10^{-9.87}$ (325)

$HTeO_4^- = H^+ + TeO_4^{--}$; $K_{298.1} = 4 \times 10^{-11}$ (122)

$H_2Te(aq) = H^+ + HTe^-$; $K_{298.1} = 10^{-2}$ (215)

$H_2TeO_3(s) + 4H^+ = Te^{++++} + 3H_2O(l)$
In HCl(aq) at 291.1°K (750) by emf method

$c_{(Cl^-)}$	$c_{(Te^{++++})}$	K_c
0.0	0.2×10^{-19}	
.001	$.49 \times 10^{-9}$	510
.005	$.78 \times 10^{-7}$	140
.01	$.14 \times 10^{-5}$	190
		Mean = 300

$TeO_2(s) + H_2O(l) = H_2TeO_3(s)$
$\Delta F^0_{291.1} = -5\ 550 \pm 500$ (750)

$H_2TeO_3(aq) = H^+ + HTeO_3^-$
$K_{298.1} = 2 \times 10^{-3}$ (122); $= 0.6 \times 10^{-5}$ (325)

$H_2TeO_4(aq) = H^+ + HTeO_4^-$
$K_{298.1} = 6 \times 10^{-7}$ (122)

N, Nitrogen

$N_2(g)$
ΔF^0, $\Delta H^0 = 0$; $C_p = 6.5 + 0.001T$ (885)

$N_2(g) = 2N(g)$; *v.* Vol. V, p. 418

$N_2(aq)$
$\Delta F^0_{298.1} = 4\ 358$ (468); for activity coefficient in aqueous salt solutions at 298.1°K, *v.* (468, 1175)

NO(g)
$C_p = 6.5 + 0.001T$ (885); $\Delta F^0_{298.1} = 20\ 869$, revised value (1193)

$\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) = NO(g)$
$\Delta F^0 = 21\ 600 - 2.50T$; $\Delta F^0_{298.1} = 20\ 850$ (885). $\Delta F^0 = 21\ 605 - 2.470T$; $\Delta H^0_{298.1} = 21\ 605$; $\Delta F^0_{298.1} = 20\ 869$, revised values (1193) *from* (419, 697, 1053, 1054); *cf.* (110, 509, 550, 551, 1026.5, 1092)

T	log K	I	Lit.
1 811	−2.038	−2.599	(1053, 1054)
1 877	−1.982	−2.434	(697)
2 023	−1.784	−2.509	(697)
2 033	−1.798	−2.395	(1053, 1054)
2 195	−1.609	−2.478	(1053, 1054)
2 580	−1.283	−2.500	(419, 1053, 1054)
2 675	−1.245	−2.376	(419, 1053, 1054)

NO(l)
$C_p = 17.35$ (402); $\Delta F^0_{298.1} = 24\ 594$; $\Delta H^0_{298.1} = 20\ 228$ (1193)

NO(l) = NO(g)

$\Delta F^0 = 4\ 567 + 10.85T \ln T - 0.0005T^2 - 89.484T$ (range 110 to 125°K); $\Delta F^0_{298.1} = -3\ 725$; $\Delta H^0_{298.1} = 1\ 377$; vapor pressures corrected for fugacity of liquid and vapor (1193) *from* (501, 602); *cf.* (481.5)

NO(s)

$C_p = -1.2 + 0.15T - 0.00048T^2$ (40 – 120°K) (1193) *from* (402); $\Delta F^0_{298.1} = 26\ 398$; $\Delta H^0_{298.1} = 17\ 926$ (1193)

NO(s) = NO(g)

$\Delta F^0 = 3\ 765 - 7.7T \ln T + 0.0745T^2 - 0.00008T^3 - 2.407T$ (range 73 to 110°K); $\Delta F^0_{298.1} = -5\ 529$; $\Delta H^0_{298.1} = 3\ 679$; vapor pressures corrected for fugacity of solid and vapor (1193) *from* (501, 602, 1038); *cf.* (481.5)

NO_2(g)

$C_p = 7.0 + 0.0071T - 0.00000086T^2$ (885); $\Delta H^0_{298.1} = 8\ 018$; $\Delta F^0_{298.1} = 11\ 920$ (885); $= 12\ 495$, revised value (1193)

NO(g) + ½O_2(g) = NO_2(g)

$\Delta F^0 = -14\ 170 + 2.75T \ln T - 0.0028T^2 + 0.00000031T^3 + 2.73T$; $\Delta F^0_{298.1} = -8\ 930$ (885). $\Delta F^0 = -13\ 000 + 2.75T \ln T - 0.0028T^2 + 0.00000031T^3 + 0.656T$; $\Delta F^0_{298.1} = -8\ 374$; $\Delta H^0_{298.1} = -13\ 587$, revised values (1193) *from* (130, 134, 1224)

NO_2^-; $\Delta F^0_{298.1} = -8\ 500$ (885)

NO_3^-; $\Delta F^0_{298.1} = -26\ 500$ (885)

HNO_2(aq); $\Delta F^0_{298.1} = -13\ 070$ (885)

HNO_2(aq) = $H^+ + NO_2^-$

$K_{298.1} = 0.00045$ (1334); $= 0.00056$ (337); $\Delta F^0_{298.1} = 4\ 570$ (885)

$H^+ + NO_3^-$ + 2NO(g) + H_2O(l) = 3HNO_2(aq)

$\Delta F^0_{298.1} = 2040$ (885)

$m_{(HNO_3)}$	$K_{298.1}$	Lit.
0.05	0.032	(1294)
.1	.024	(1294)
.1	.030	(866)
.2	.022	(1294)
.2	.019	(866)

HNO_3(g); $\Delta F^0_{298.1} = -18\ 210$ (885)

2HNO_3(g) = H_2O(g) + 2NO_2(g) + ½O_2(g) (127)

3NO_2(g) + H_2O(g) = NO(g) + 2HNO_3(g) (885) *from* (223)

T	283.1	298.1	323.1	348.1
ΔF^0	−3 000	−3 190	−3 250	−3 810

HNO_3(aq) (885) *from* (223)

$\Delta F^0_{298.1} = -26\ 500$ (885)

m	0.05	0.1	0.2	0.5	1
γ	0.83	0.79	0.76	0.73	0.73
m	2	4	9	16	36
γ	0.79	0.92	1.16	1.45	2.18

HNO_3(aq) = $H^+ + NO_3^-$; $\Delta F^0 = 0$ (885)

HNO_3(aq) = HNO_3(g)

$\Delta F^0 = 8\ 290$ (885) *from* (223); *cf.* (84, 312, 1115, 1295, 1296, 1297, 1396, 1522)

NH_3(g)

$C_p = 8.04 + 0.0007T + 0.0000051T^2$; $\Delta F^0_{298.1} = -3\ 910$ (885)

Activity functions of ammonia vapor in mixtures with nitrogen at 318.1°K (1190) *from* (921)

P	x_2 (NH_3)	f_2	f_2^0	$f_2^0 x_2$	k_2	k_2/f_2^0	k_2/P
7.123	1.000	6.759	6.759	6.759	6.759	1.000	0.952
10.133	0.7040	6.774	9.40	6.615	9.62	1.022	.949
11.716	.6393	6.783	10.73	6.86	10.61	0.990	.906
13.272	.5655	6.791	12.02	6.88	12.05	1.003	.905
23.695	.3313	6.845	19.75	6.54	20.67	1.046	.872
32.818	0.2478	6.894	25.45	6.26	27.80	1.078	0.846
47.912	.1743	6.974	(32.65)	(5.69)	40.00	(1.225)	.835
60.864	.1484	7.043	(37.09)	(5.50)	47.45	(1.279)	.780

Activity functions of ammonia vapor in mixtures with 1:3 nitrogen-hydrogen mixtures (1190) *from* (831)

P	f_2	x_2	k_2/P	f_2	x_2	k_2/P	f_2	x_2	k_2/P
	(253.1°)			(273.1°)			(291.1°)		
v.p	1.833	1.0000	0.972	4.045	1.0000	0.954	7.351	1.0000	0.927
50	1.946	0.0570	.683	4.271	0.1000	.854	7.716	0.1885	.818
100	2.071	.0339	.611	4.533	.0581	.780	8.174	.1050	.778
300	2.655	.0150	.590	5.753	.0340	.564	10.309	.0597	.575
600	3.858	.0126	.510	8.219	.0246	.555	14.608	.0476	.512
1000	6.344	.0109	.582	13.239	.0209	.634	23.241	.0403	.577

The vapor pressure of ammonia was taken as 1.88 at 253.1°, 4.24 at 273.1° and 7.93 atm. at 291.1°, and the molal volumes as 25.84 at 253.1°, 26.69 at 273.1° and 27.74 cm³ at 291.1°K.

½N_2(g) + $\frac{3}{2}H_2$(g) = NH_3(g)

$\Delta F^0 = -9\ 500 + 4.96T \ln T + 0.000575T^2 - 0.00000085T^3 - 9.61T$; $\Delta F^0_{298.1} = -3\ 910$ (885) *from* (537–544, 955); *cf.* (183, 185, 281, 486, 487, 488, 535, 536, 552, 553, 554, 556, 557, 558, 735, 736, 830, 832, 838, 1055)

$$-R \ln K_p = -9\ 274 + 4.96T \ln T + 0.000575T^2 - 0.00000085T^3 - 9.860T \quad (1193)$$

T	K_p	I	T	K_p	I
P = 10 atm. (832)					
598.1	0.0401	−9.845	698.1	0.00919	−9.856
623.1	.0266	−9.848	723.1	.00659	−9.815
648.1	.0181	−9.839	748.1	.00516	−9.907
673.1	.0129	−9.872	773.1	.00381	−9.851
P = 30 atm. (832)					
623.1	0.0273	−9.900	723.1	0.00676	−9.866
648.1	.0184	−9.872	748.1	.00515	−9.903
673.1	.0129	−9.872	773.1	.00386	−9.877
698.1	.00919	−9.857			

T	K_p	T	K_p	T	K_p
P = 50 atm. (832)					
623.1	0.0278	698.1	0.00932	748.1	0.00513
648.1	.0186	723.1	.00690	773.1	.00388
673.1	.0130				
P = 100 atm. (832)					
648.1	0.0202	698.1	0.00987	748.1	0.00532
673.1	.0137	723.1	.00725	773.1	.00402
P = 300 atm. (832)					
723.1	0.00884	748.1	0.00674	773.1	0.00498
P = 600 atm. (832)					
723.1	0.01294	748.1	0.00895	773.1	0.00651
P = 1000 atm. (832)					
723.1	0.02328	748.1	0.01493		

NH_3(l)

$C_p = 47.3 - 0.2476T + 0.000516T^2$ (1193); *cf.* (402, 760); $\Delta F^0_{298.1} = -2\ 620$ (885), $-2\ 570$; $\Delta H^0_{298.1} = -16\ 258$, revised value (1193)

NH_3(l) = NH_3(g)

$\Delta F^0 = 10\ 450 + 39.26T \ln T - 0.1241T^2 + 0.0000850T^3 - 233.791T$ (range 189 to 398°K); $\Delta F^0_{298.1} = -1\ 290$ (885), $-1\ 340$; $\Delta H^0_{298.1} = 5\ 264$; corrected for fugacity of liquid and vapor (1193) *from* (81, 181, 227, 255, 321, 760, 1405); $\Delta H^0_{239.9} = 5\ 730$ (445); *cf.* (311) *and* Vol. V, p. 138

$NH_3(s)$

$C_p = 0.20 + 0.0639T$ (70 − 170°K); $\Delta F^0_{298.1} = -1\ 585$; $\Delta H^0_{298.1} = -15\ 109$ (1193) *from* (402)

$NH_3(s) = NH_3(g)$

$\Delta F^0 = 7\ 336 - 7.84T \ln T + 0.0316T^2 - 0.00000085T^3 + 2.916T$ (range 146 to 196°K); $\Delta F^0_{298.1} = -2\ 325$; $\Delta H^0_{298.1} = 4\ 125$; vapor pressures corrected for fugacity of solid and vapor (1193) *from* (181, 227, 746, 1038)

$NH_3(aq)$

$\Delta F^0_{298.1} = -6\ 300$ (885); for activity coefficient in aqueous salt solutions at 298.1°K, *v.* (7, 1175, 1181, 1226)

$NH_3(g) = NH_3(aq)$

$\Delta F^0_{298.1} = -2\ 390$ (885); *cf.* (7, 464, 904, 1226)

NH_3(in C_7H_8, toluene) + $H_2O(l) = NH_4OH(aq)$ (1181)

T	$x_{(NH_3)}$	$m_{(NH_4OH)}$	K_m
298.1	0.0004006	0.7347	1 833
	.0004629	.8394	1 813

NH_4^+; $\Delta F^0_{298.1} = -18\ 930$ (885)

$NH_4OH(aq)$; $\Delta F^0_{298.1} = -62\ 860$ (885)

$NH_3(aq) + H_2O(l) = NH_4OH(aq)$; $\Delta F^0 = 0$ (885)

$NH_4OH(a) = NH_4^+ + OH^-$

$K_{298.1} = 18.1 \times 10^{-6}$ (1083); $\Delta F^0_{298.1} = 6\ 470$ (885); *cf.* (800)

T	$K \times 10^6$	T	$K \times 10^6$	T	$K \times 10^6$
291.1	17.2	348.3	16.4	429.1	6.28
298.1	18.1	373.1	13.5	491.1	1.80
324.1	18.1	397.9	10.4	579.1	0.093

$NOCl(g)$; $\Delta F^0_{298.1} = 16\ 010$ (885)

$NO(g) + \frac{1}{2}Cl_2(g) = NOCl(g)$

$\Delta F^0 = -9\ 100 + 14.3T$; $\Delta F^0_{298.1} = -4\ 840$ (885) *from* (1453); *cf.* (1446, 1464)

T	$\log K_p$	T	$\log K_p$	T	$\log K_p$
503	0.822	605	0.152	695	−0.248
531	0.608	641	0.025	704	−0.316
589	0.206	678	−0.133	733	−0.497

$HNO_3(aq) + 3HCl(aq) = NOCl(g) + Cl_2 + 2H_2O(l)$ (184)

$NH_4Cl(s)$; $\Delta F^0_{298.1} = -47\ 810$ (1189) *from* (193, 1231)

$NH_4Cl(g) = NH_3(g) + HCl(g)$ (1376, 1377); *cf.* (44, 534, 717, 1060, 1164, 1169, 1170, 1287)

T.......	553	563	573	583	593	603
K_p......	0.0790	0.1996	0.2333	0.3082	0.4030	0.544

$\frac{1}{2}H_2(g) + NH_4OH(0.05m) + HgCl(s) = Hg(l) + NH_4Cl(s) + H_2O$ (in satd. NH_4Cl)

$E_{298.1} = 0.6924$ (193); $\Delta H = -70\ 600$; $\Delta F^0_{298.1} = -14\ 670$ (1189)

NH_4Cl (α-s); $\Delta F^0_{298.1} = -47\ 810$ (1189) *from* (193)

$NH_4Cl(\beta\text{-s}) = NH_4Cl$ (equilib. vapor)

$\log p = -1\ 920.357/T + 9.778609 \log T - 24.081$ (1371); *cf.* (649, 712, 1169, 1170, 1196, 1379, 1510)

$NH_4Cl(\alpha\text{-s}) = NH_4Cl(\beta\text{-s})$

$\Delta H = 1\ 030$ (1303); $\Delta F^0_{457.6} = 0$ (1302)

$NH_4Cl.3NH_3(s) = NH_4Cl(s) + 3NH_3(g)$ (1457) (E)

T	P	T	P
237.1	0.184	262.3	0.730
244.5	.217	267.1	.961
246.1	.237	273.1	1.362
250.1	.316	276.1	1.651
253.1	.408	278.1	1.862
255.4	.474	279.1	1.947
257.1	.520	280.1	2.184
260.1	.638	281.1	2.368

$NH_4Cl.6NH_3(s) = NH_4Cl.3NH_3(s) + 3NH_3(g)$ (1457) (E)

T	P	T	P
237.1	0.763	246.1	1.178
240.1	.875	248.1	1.289
242.0	.987	250.1	1.395
244.5	1.098	252.1	1.487

$NO(g) + \frac{1}{2}Br_2(g) = NOBr(g)$ (1449)

$NH_4Br(g) = NH_3(g) + HBr(g)$ (1376, 1377); *cf.* (1288)

T	K_p	T	K_p	T	K_p
573	0.00192	613	0.0260	643	0.0186
593	.0233	623	.0202	653	.0167
603	.0260	633	.0203	661	.0053

$NH_4Br(\alpha\text{-s}) = NH_4Br(\beta\text{-s})$

$\Delta F^0_{410.4} = 0$ (1304)

$NH_4Br(\beta\text{-s}) = NH_4Br$ (equilib. gas)

$\log P = -2\ 056.541/T + 9.54014 \log T - 23.8655$ (1371); *cf.* (712)

$NH_4Br.NH_3(s) = NH_4Br(s) + NH_3(g)$ (1458) (E)

T	P	T	P
246.1	0.118	273.1	0.461
249.1	.145	282.1	.770
254.1	.191	287.9	1.020
263.1	.276	293.1	1.349
266.5	.322	299.1	1.737
270.1	.382	304.1	2.184

$NH_4Br.3NH_3(s) = NH_4Br.NH_3(s) + 2NH_3(g)$ (1247, 1458) (E)

T	P	T	P
252.1	0.213	279.6	1.072*
255.1	.243	280.1	1.105
258.1	.299	282.9	1.197
263.1	.412	287.7	1.506
268.1	.562	292.6	1.796
273.1	.759	298.1	2.105
276.1	.905	303.2	2.428
278.1	.921		

* Quadruple point. Liquid phase containing 1 mole NH_4Br to 2.63 moles NH_3.

$NH_4Br.6NH_3(s) = NH_4Br.3NH_3(s) + 3NH_3(g)$ (1458) (E)

T	P	T	P
241.1	0.711	258.1	1.375
245.3	.862	261.1	1.579
247.6	.908	263.1	1.684
247.8	.921	265.1	1.868
251.3*	1.099	268.1	2.092
254.3	1.184	270.3	2.295

* Above 253°K, the compound fuses.

$NH_4Br_3(s) = ?$ (382) (E)

T	P	T	P
290.1	0.026	347.3	0.395
322.6	.138	357.3	.625
333.5	.209	365.4	.882

$NH_4BrCl_2(s) = ?$ (382) (E)

T	P	T	P
291.6	0.092	321.6	0.586
303.1	.191	327.1	.800
314.6	.408	328.9	.895

$NH_4I(g) = NH_3(g) + HI(g)$ (1376, 1377); *cf.* (1288)

T	$d_{vap.}$, g/cm³	T	$d_{vap.}$, g/cm³
573	0.000181	633	0.000874
593	.000307	643	.00105
613	.000488	653	.00129
623	.000647		

$NH_4I(\alpha\text{-s}) = NH_4I(\beta\text{-s})$; $\Delta F^0_{257.1} = 0$ (1304)

$NH_4I(\beta\text{-s}) = NH_4I$ (equilib. gas)

$\log p = -7\,714.591/T - 10.04345 \log T + 39.8148$ (1371); *cf.* (712)

$NH_4I.NH_3(s) = NH_4I(s) + NH_3(g)$ (1458) (E)

T	P	T	P
246.1	0.013	282.1	0.132
257.1	.022	292.1	.236
259.1	.026	300.1	.368
263.1	.036	308.1	.597
267.3	.050	323.1	1.237
273.1	.075	329.1	1.500

$NH_4I.3NH_3(s) = NH_4I.NH_3(s) + 2NH_3(g)$ (1458) (E)

T	P	T	P
246.1	0.171	273.1	0.500
250.1	.178	282.1	.763
254.1	.197	287.7	.921
259.1	.237	292.6	1.105
263.3*	.309	298.1	1.309
268.1	.382	303.1	1.526

* The compound becomes liquid above 261°K.

$NH_4I.6NH_3(s) = NH_4I.3NH_3(s) + 3NH_3(g)$ (1458) (E)

T	P	T	P
244.1*	0.572	268.1	1.362
248.1	.671	273.1	1.645
251.9	.757	277.8	1.862
256.1	.862	282.5	2.132
260.3	1.073	284.5	2.283
267.1	1.316		

* The compound becomes liquid above 245.1°K.

$NH_4IBr_2(s) = (?)$ (382) (E)

T	P	T	P
380.1	0.086	417.6	0.412
397.6	.182	427.1	.612
407.1	.268	434.1	.842

$NH_3(g) + H_2S(g) = NH_4SH(s)$

$\Delta F^0 = -22\,240 + 70.148T$ (range 277 to 300°K); $\Delta F^0_{298.1} = -1\,329$; $\Delta H^0_{290.1} = -22\,240$ (1193) *from* (670, 935, 1493)

$N_2O(aq)$

Activity coefficient in aqueous salt solutions (1175) *from* (468, 767, 945)

$N_2O(g) = N_2O(aq)$; $\Delta F^0_{298.1} = 2\,268$ *from* (468)

$N_2O.xH_2O(?) = N_2O(g) + H_2O(l)$ (1469, 1470, 1472, 1473) (E)

T	P	T	P
264.1*	3.6	280.2	21.5
268.4*	5.8	283.8†	34.7
273.1	9.7	$\Delta H = 15\,000$	

* Ice present.
† Critical decomposition point above 285.1°K.

$N_2O_4(g)$

$C_p = 2 \times C_p(NO_2)(g)$; $\Delta H^0_{298.1} = 3\,036$ (1193); $\Delta F^0_{298.1} = 22\,640$ (885); $= 23\,853$, revised value (1193)

$2NO_2(g) = N_2O_4(g)$

$\Delta F^0 = -13\,600 + 41.6T$; $\Delta F^0_{298.1} = -1\,200$ (885). $\Delta F^0 = -13\,000 + 39.830T$; (range 273 to 404°K); $\Delta F^0_{298.1} = -1\,127$; $\Delta H^0_{298.1} = -13\,000$, revised values (1193) *from* (130, 308, 885, 1327); *cf.* (1280, 1306)

N_2O_4 (in $CHCl_3$) $= 2NO_2$ (in $CHCl_3$) (885) *from* (315, 316)

$x_{(CHCl_3)}$	$x_{(N_2O_4)}$	$x_{(NO_2)}$	$K \times 10^8$
0.0	1.00	0.00094	88
.27	0.73	.00080	87
.46	.54	.00067	83
.70	.30	.00045	67
.875	.125	.00029	66
.934	.066	.00019	52
.950	.050	.00015	43
.963	.037	.00012	35
.982	.018	.00010	49

$2N_2O_4(l) + H_2O(l) = 2HNO_3(l) + N_2O_3(l)$ (1225)

$NH_4NO_3(s) = NH_4NO_3$ (equilib. vapor)

Vapor density = 20.66 at 553.1°K, $P = 0.153$ atm. (1197)

$2NH_4NO_3.5NH_3(s) = 2NH_4NO_3(s) + 5NH_3(g)$ (1459) (E)

T	P	T	P
243.1	0.118	283.2	0.691
247.1	0.151	287.1	0.789
255.1*	0.224	291.5	0.941
263.1	0.329	293.9	1.007
273.1	0.480	298.1	1.234

* The compound becomes liquid above 251°K.

$N_3H(aq) = H^+ + N_3^-$ (1100)

T..................	273.1	278.1	283.1	288.1	293.1
$K \times 10^5$.............	0.8	0.9	1.0	1.1	1.2

$N_2O_3(g) + NO_2(g) + NO(g) = N_4O_6(g)(?)$ (726)

$NH_4N_3.2NH_3(s) = NH_4N_3(s) + 2NH_3(g)(?)$ (E)

$P = 0.300$ at 240.1°K (213)

P, Phosphorus

$4P$(equilib. vapor) $= P_4(g)$ (106, 1463)

T	Vapor density*	T	Vapor density*
773	4.35	1 757	3.632
1 313	4.50	1 950	3.226

* $P_4(g)$; v.d. = 4.294 referred to air.

$HPO_4^{--} = H^+ + PO_4^{---}$

$K_{291.1} = 3.6 \times 10^{-13}$ (1); $K_{291.1} = 2 \times 10^{-12}$ (122)

$H_2PO_3^- = H^+ + HPO_3^{--}$; $K_{298.1} = 2 \times 10^{-5}$ (122)

$H_2PO_4^- = H^+ + HPO_4^{--}$

$K_{291.1} = 2.0 \times 10^{-7}$ (1); $= 8 \times 10^{-7}$ (122); $= 5.5 \times 10^{-8}$ (121); *cf.* (997, 1162)

$PH_3.6H_2O(?) = PH_3(g) + 6H_2O(l)$ (233, 439) (E)

T	P	T	P
266.70*	1.0	284.1	6.7
273.1*	1.63	287.1	8.9
275.3	2.3	288.1	9.8
277.1	3.0	290.1	11.0
279.9	3.9	293.1†	15.1
282.1	5.1		

* From (439); all other values from (233).
† Critical decomposition point at 301.1°K.

$H_3PO_3(aq) = H^+ + H_2PO_3^-$; $K_{298.1} = 0.05$ (122)

$H_3PO_4(aq) = H^+ + H_2PO_4^-$

$K_{291.1} = 0.011$ (1); $K_{298.1} = 0.009$ (1268); $= 0.0083$ (1344); *cf.* (782, 1162)

$PCl_3(g) + Cl_2(g) = PCl_5(g)$ (232)

T	Vapor density ($P = 1$)	T	Vapor density ($P = 1$)	T	Vapor density ($P = 1$)
455.1	5.08	503.1	4.80	561.1	3.67
463.1	4.99	523.1	4.00	573.1	3.65
473.1	4.85	547.1	3.84		

$PCl_3(g) + Cl_2(g)$.—(*Continued*)

c = mole per liter at saturation; $PCl_5(s)$ in equilib. (1377)

T	c	% dissoc.	P
363.1	0.000945	100+	0.024
373.1	.00159	100+	.046
383.1	.00273	2.8	.088
393.1	.00446	7.1	.154
403.1			.251
413.1	.01098	4.0	.387
423.1	.01655	2.0	.586
433.1	.02368	4.8	.882

$PCl_5(s) = PCl_5$ (equilib. vapor) (1371); *cf.* (262, 640, 1059, 1161, 1376, 1377)

T	P	T	P
363.1	0.0237	433.1	0.882
393.1	.154	435.9	1.000
413.1	.387	470.1	1.209
423.1	.586		(liquid)

$PH_4I(s) = PH_4I$ (equilib. vapor) (1371); *cf.* (714)

T	P	T	P
288.1	0.0474	333.1	0.8684
303.1	.1419	335.7	1.00
313.1	.2618	339.1	1.207
323.1	.4844		

$HP_2O_7^{---} = H^+ + P_2O_7^{----}$; $K_{291.1} = 3.6 \times 10^{-9}$ (1)

$H_2P_2O_7^{--} = H^+ + HP_2O_7^{---}$; $K_{291.1} = 2.9 \times 10^{-7}$ (1)

$H_3P_2O_7^- = H^+ + H_2P_2O_7^{--}$; $K_{291.1} = 0.011$ (1)

$H_4P_2O_7(aq) = H^+ + H_3P_2O_7^-$; $K_{291.1} = 0.14$ (1)

As, Arsenic

As (gray); ΔF^0, $\Delta H^0 = 0$

$As_2(g) = 2As(g)$ (1158)

T..........	1 073	1 173	1 273	1 373	1 473
K..........	0.000211	0.00105	0.00414	0.01342	0.0368

$As_4(g) = 2As_2(g)$ (1158)

T..............	1 073	1 173	1 273	1 373	1 473
K..............	0.00397	0.0118	0.0296	0.0658	0.1316

$HAsO_2$ (in $C_5H_{12}O$, amyl alcohol) $= HAsO_2(aq)$; *see* Vol. III, p. 421

$AsO_2^- + HAsO_2(aq) = HAs_2O_4^-$; $K_{298.1}$ = 0.2 to 0.7 (32)

$As(s) + \frac{3}{2}H_2(g) = AsH_3(g)$ (518)

$AsH_3.6H_2O(?) = AsH_3(g) + 6H_2O(l)$ (439) (E)

ΔH = 17 750 to 18 830

T	P_{AsH_3}	T	P_{AsH_3}
273.1	0.807	286.1	3.83
274.7	1.000	291.35	6.79
277.25	1.289	294.1	8.85
283.1	2.65	301.3*	17.5

* Critical decomposition point.

$H_3AsO_3(aq) = AsO^+ + OH^- + H_2O(l)$

$K_{298.1} = 0.5 \times 10^{-14}$; corrected for error in calc. (1507)

$H_3AsO_3(aq) = H^+ + H_2AsO_3^-$

$K_{298.1} = 2.1 \times 10^{-8}$ (1561)

$H_3AsO_4(aq) = H^+ + H_2AsO_4^-$

$K_{298.1} = 0.00432 + 0.004c^{1/2}$ (1507); *cf.* (1486)

$c_{(HCl)}$............	0.05057	0.1011	0.1268
$K_{298.1}$..........	0.00530	0.00560	0.00575

$H_3AsO_3(aq) + H_2O(l) = H_3AsO_4(aq) + 2H^+ + 2E^-$

$\Delta F^0_{298.1} = 26\ 923$; $E^0_{298.1} = -0.5834$ (1507)

$H_3AsO_3(aq) + I_3^- = H_3AsO_4(aq) + 2H^+ + 3I^-$

Corrected for errors in calc. (1507); *cf.* (1236, 1237); for $\mu_c^{1/2}$ = *ca.* 0.3 – 0.4, $\Delta F^0_{298.1}$ = 1 700

d^{25}_{25}	$c_{(\Sigma I)}$	$c_{(\Sigma As)}$	$10^3 \times c_{(I_2)}$	$\mu_c^{1/2}$	K_c
1.0232	0.18568	0.10128	0.0625	0.392	0.0546
1.0250	.20686	.10121	.0943	.400	.0597
1.0140	.09059	.05198	.00727	.290	.0555
1.0155	.10734	.04937	.0720	.300	.0580
1.0148	.10248	.04935	.0446	.300	.0595
1.0144	.10140	.04934	.0394	.298	.0601
			.0175	.333	.0543
			Mean K_c = 0.057 ± 4%		

$As_2O_5.xH_2O(s) = ? + yH_2O(g)$ (844) (E)

x	T	P	x	T	P
0.04	303.1	0.0016	1.89	303.1	0.0054
0.04	430.1	.026	2.2	373.1	1.044 to
1.48–0.19	430.1	.329			1.052
1.70	373.1	.042	4	303.1	0.0054

$2As_2S_2(g) + 4H_2(g) = 4H_2S(g) + As_4$

P_{H_2S}/P_{H_2} = 3.70 at 883°K (1124)

$As_2Se_5(g) = ?$ (1417)

$As_4S_4(g) = ?$ (1417)

Sb, Antimony

$Sb(s) = Sb^{+++} + 3E^-$; $E^0_{298.1} = -0.244$ (701)

$Sb_4(g) = 2Sb_2(g)$ (105)

T	w	Average composition
1 845	310	$Sb_{2.96}$
1 913	282	$Sb_{2.68}$

$Sb(s) + 4OH^- + 3E^- = SbO_2^- + 2H_2O(l)$

$E_{293.1} = 0.675 - 0.058/3 \log m_{SbO_2^-}$ in 10m KOH (524)

$SbO_2^- + 2OH^- + 2E^- = SbO_3^- + H_2O(l)$

$E_{293.1} = 0.589 - 0.058/2 \log m_{SbO_3^-}/m_{SbO_2^-}$ in 10m KOH (524)

$Sb_2O_4(s) = Sb_2O_3(s) + \frac{1}{2}O_2(g)$

At 1223°K, P = 1.00 (431)

$Sb_2S_3(s) + 3H_2(g) = Sb_2(s) + 3H_2S(g)$ (1125)

T........................	713	783	828	883	898
% gas as H_2S............	43.22	48.6	51.8	56.01	56.92

Bi, Bismuth

$Bi(s) + 4OH^- = BiO_2^- + 2H_2O(l) + 3E^-$ (524)

$\frac{3}{2}H_2(g) + BiOCl(s) = Bi(s) + H^+ + Cl^- + H_2O(l)$ (1085)

Pt, H_2(1 atm.), HCl (xm), HCl (xm + BiOCl(s)), Bi(s) (1085)

$m_{(HCl)}$	$E_{298.1}$	$m_{(HCl)}$	$E_{298.1}$	$E_{288.1}$	$E_{308.1}$
0.000983	0.28249	0.1041	0.20221	0.20447	0.20011
.001010	.28212	.2304	.08887	.19160	.18617
.003175	.26071	.5005	.17563		
.009022	.24293				
.02007	.22947		$E^0_{298.1}$	$E^0_{288.1}$	$E^0_{308.1}$
.04586	.21606		0.1599	0.1635	0.1563

$BiOCl(s) + 2H^+ + 3Cl^- = H_2O(l) + BiCl_4^-$* (1082.1); *cf.* (678.5)

d^{25}_4	$c_{(\Sigma H+)}$	$c_{(\Sigma Cl)}$	$c_{(\Sigma Bi)}$
1.002	0.3438	0.3477	0.00130
1.007	.4237	.4350	.00376
1.009	.4295	.4414	.00396
1.009	.4698	.4892	.00646
1.010	.4960	.5221	.00869
1.011	.5006	.5276	.00899
1.012	.5399	.5796	.01323
1.013	.5714	.6244	.01767
1.015	.5742	.6299	.01856

$BiOCl(s) + 2H^+ + 3Cl^-$.—(*Continued*)

d_4^{25}	$c_{(\Sigma H+)}$	$c_{(\Sigma Cl)}$	$c_{(\Sigma Bi)}$
1.015	0.6222	0.7038	0.02720
1.018	.6434	.7375	.03138
1.020	.6537	.7579	.03473
1.025	.7223	.8824	.05338
1.028	.7343	.9125	.05936
1.036	.8079	1.0760	.08937
1.044	.8746	1.2277	.1177
1.048	.8752	1.2724	.1324
1.055	.9488	1.4348	.1620
1.061	.9891	1.5321	.1810
1.066	1.016	1.6235	.2025
1.066	1.020	1.6350	.2050
1.075	1.065	1.7706	.2352
1.083	1.105	1.9021	.2657
1.122	1.293	2.5578	.4216
1.157	1.481	3.1865	.5685
1.185	1.599	3.6366	.6792
1.221	1.758	4.2552	.8324
1.237	1.799	4.5056	.9022
1.288	2.025	5.325	1.100
1.329	2.115	6.066	1.317

* Some Bi^{+++} and some $BiCl_5^{--}$ also present.

$Bi_2(SO_4)_3 = (?) + SO_2(g) + \frac{1}{2}O_2(g)$ (636)

C, Carbon

C (graphite)

$\Delta F^0, \Delta H^0 = 0$ (880, 885); $C_p = 1.1 + 0.0048T - 0.0000012T^2$ (885)

C (diamond)

$\Delta F^0_{298.1} = 390$; $\Delta H^0_{298.1} = 180$ (885)

C (graphite) = C (diamond)

$\Delta F^0 = -27 + 0.7T$ (885) *from* (1264); *cf.* (1263)

CO(g)

$C_p = 6.5 + 0.001T$; $\Delta F^0 = -26\,600 - 2.15T \ln T + 0.00215T^2 - 0.0000002T^3 - 8.20T$; $\Delta F^0_{298.1} = -32\,510$ (885)

CO_2(g)

$C_p = 7.0 + 0.0071T - 0.00000186T^2$; $\Delta F^0 = -94\,110 + 0.60T \ln T - 0.00065T^2 + 0.00000011T^3 - 3.74T$; $\Delta F^0_{298.1} = -94\,260$ (885)

Activity function of carbon dioxide in nitrogen and in hydrogen (1190)

T	Gas	P	x_2	a_2 (l)	$a_2/_{N_2}$	$f_2/_{N_2}$	k_2/P
221.5	N_2	40.6	0.222	1.086	4.89	29.55	0.728
		60.5	.182	1.133	6.22	37.60	.621
		74.6	.176	1.167	6.63	40.07	.537
		78.4	.176	1.176	6.68	40.35	.515
		92.9	.179	1.212	6.77	40.90	.440
		108.4	.188	1.252	6.66	40.25	.371
		122.0	.200	1.289	6.44	38.93	.319
		125.8	.205	1.299	6.33	38.28	.304
		139.9	.230	1.338	5.82	35.13	.251
		143.2	.237	1.347	5.68	34.34	.240
		146.6	.248	1.357	5.47	33.05	.225
		148.6	.256	1.364	5.33	32.19	.216
		153.4	.270	1.376	5.10	30.80	.201
	H_2	78.4	.120	1.176	9.80	59.15	.755
		95.3	.105	1.218	11.60	70.08	.736
		100.6	.101	1.232	12.20	73.7	.733
		112.8	.094	1.264	13.45	81.2	.720
		157.3	.084	1.387	16.50	99.8	.634
273.1	N_2	53.7	.744	1.12	1.50	36.0	.67
		63.9	.668	1.12	1.68	40.3	.63
		65.1	.665	1.15	1.73	41.5	.64

CO_2(g).—(*Continued*)

T	Gas	P	x_2	a_2 (l)	$a_2/_{N_2}$	$f_2/_{N_2}$	k_2/P
273.1	N_2	68.2	0.642	1.16	1.81	43.4	0.64
		75.8	.616	1.17	1.90	45.6	.60
		76.5	.615	1.18	1.92	46.1	.60
		81.9	.603	1.19	1.98	47.4	.58
		88.6	.594	1.21	2.04	48.9	.55
	H_2	78.4	.594	1.18	1.99	47.8	.61
		92.4	.534	1.22	2.29	54.9	.60
		103.0	.503	1.24	2.47	59.3	.58
		122.0	.458	1.30	2.84	68.1	.56

$CO(g) + \frac{1}{2}O_2(g) = CO_2(g)$

$\Delta F^0 = -67\,510 + 2.75T \ln T - 0.0028T^2 + 0.00000031T^3 + 4.46T$; $\Delta F^0_{298.1} = -61\,750$ (885); *cf.* (118, 373, 1146)

T	% dissoc.	K	I	Lit.
1 395	0.0142	837 000	4.7	(821)
1 400	.015	781 000	4.6	(1058)
1 443	.025	358 000	4.8	(821)
1 478	.032	247 000	4.4	(1058)
1 481	.028	295 000	3.9	(821)
1 498	.047	138 000	4.9	(821)
1 565	.064	87 300	4.9	(821)
1 823	.4	5 600	3.3	(915)

$CO_2(g) + H_2(g) = CO(g) + H_2O(g)$

$\Delta F^0 = 10\,100 - 1.81T \ln T + 0.00445T^2 - 0.00000068T^3 - 0.54T$; $\Delta F^0_{298.1} = 7\,240$ (885); *cf.* (16, 17, 19, 216, 368, 377, 401, 535, 555, 585, 588, 590, 631)

T (566, 567)	K	I
959	0.534	−0.59
1 059	0.840	−0.53
1 159	1.197	−0.56
1 259	1.571	−0.52
1 278	1.620	−0.49
1 359	1.960	−0.50
1 478	2.126	−0.23
1 678	2.490	−0.06

T (559)	K	I
1 503	3.05	−0.65
1 528	2.68	−0.51
1 538	2.85	−0.58
1 582	2.72	−0.37
1 597	2.93	−0.47
1 643	3.26	−0.64
1 768	3.83	−0.61
1 783	3.66	−0.47
1 797	3.86	−0.55
1 824	3.56	−0.32

T (364)	K	
967	1.56	
1 002	1.58	
1 009	1.73	
1 017	1.66	

C (graphite) + $CO_2(g) = 2CO(g)$

$\Delta F^0 = 40\,910 - 4.9T \ln T + 0.00495T^2 - 0.00000051T^3 - 12.66T$; $\Delta F^0_{298.1} = 29\,240$ (885) *from* (1210); *cf.* (25, 160, 283, 284, 405, 406, 407, 408, 700, 969, 1211, 1212, 1307, 1326, 1432)

T	K	I
1 123	14.11	−12.16
1 173	43.07	−12.73
1 223	73.77	−12.43
1 273	167.5	−12.72
1 323	268.3	−12.46

C (graphite) + $CO_2(g)$.—(*Continued*)

T	K	I
1 373	664.7	−13.15
1 473	1 665	−12.95
		Average = −12.66

$2CO_2(g) + \frac{1}{2}S_2(g) = 2CO(g) + SO_2(g)$

$\Delta F^0 = 51\ 760 - 2.75T \ln T + 0.0028T^2 - 0.00000031T^3 - 7.866T$, corrected for COS(g) (885) *from* (414)

No. Exps.	T (mean)	log K	I
4	1 275	−3.56	−7.789
4	1 460	−2.38	−7.943

$CO_2(aq)$

$\Delta F^0_{298.1} = -92\ 250$ (885); for activity coefficient in aqueous salt solutions, *v.* (1175) *from* (422, 468)

$CO_2(g) = CO_2(aq)$

$K_{298.1} = 0.0338$ (885) *from* (145, 744); $\Delta F^0_{298.1} = 2\ 010$ (885). $K_{298.1} = 0.037$; $\Delta F^0_{298.1} = 1\ 954$; $\Delta H = -4\ 900$, revised values (1175); *cf.* Vol. III, p. 260

$CO_2.6H_2O(?) = CO_2(g) + 6H_2O(l)$ (1472, 1473, 1554) (E)

T	P	T	P
273.1	12.3	278.4	21.8
273.58	12.7	279.2	23.3
275.8	16.7	279.9	26.1
276.7	17.9	283.1	44.3

$\Delta H = 14\ 710$

CO_3^{--}; $\Delta F^0_{298.1} = -125\ 760$ (885)

HCO_3^-; $\Delta F^0_{298.1} = -140\ 000$ (885)

$HCO_3^- = H^+ + CO_3^{--}$

$K_{298.1} = 3.7 \times 10^{-11}$; $\Delta F^0_{298.1} = 14\ 240$ (885) *from* (35, 139, 974); *cf.* (447, 1191, 1341, 1346, 1353, 1354, 1490)

$CO_3^{--} + H_2O(l) = HCO_3^- + OH^-$ (447)

$CO_2(g) + CO_3^{--} + H_2O(l) = 2HCO_3^-$

$\Delta F^0_{298.1} = -3\ 546$ (1191); *cf.* (974, 1341, 1353, 1354, 1490)

$HCOOH(l)$

$\Delta F^0_{298.1} = -84\ 040$ (885); $\Delta S^0_{298.1} = -44.5$; $\Delta F^0_{298.1} = -86\ 400$ (484, 485)

$HCOOH(aq)$; $\Delta F^0_{298.1} = -87\ 920$ (885)

$HCOOH(aq) = H_2O(l) + CO(g)$

$\Delta F^0 = 5\ 200 - 21.3T$ (885); $\Delta F^0_{298.1} = -1\ 150$ (885) *from* (164); $K_{429.4} = 90.8, 89.3, 89.6$; $K_{491.2} = 313$; $= 306$

$HCOOH(l) = HCOOH(aq)$

$\Delta F^0_{298.1} = -3\ 880$ (885) *from* (164)

$H_2CO_3(aq)$; $\Delta F^0_{298.1} = -148\ 810$ (885)

$CO_2(g) + H_2O(l) = H_2CO_3(aq)$; $\Delta F^0 = 0$ (885); *cf.* (719)

$H_2CO_3(aq) = H^+ + HCO_3^-$

$\Delta F^0_{298.1} = 8\ 810$ (885) *from* (754); *cf.* (719, 764, 982, 1165, 1435, 1491)

$H_2CO_3(aq) + CO_3^{--} = 2HCO_3^-$

$K_{298.1} = 9\ 400$ (885); *cf.* (974, 1341, 1490)

$CH_4(g)$

$C_p = 3.00 + 0.0228T - 0.00000480T^2$ (1180) *from* (343, 344, 1005); *cf.* (402, 481); $\Delta F^0 = -16\ 300 + 6.6T \ln T + 0.0008T^2 - 0.0000002T^3 - 26.0T$; $\Delta F^0_{298.1} = -12\ 800$ (885). $\Delta F^0 = -14\ 342 + 11.1T \ln T - 0.0081T^2 + 0.0000006T^3 - 51.74T$; $\Delta H^0_{298.1} = -16\ 963$; $\Delta F^0_{298.1} = -11\ 617$ (revised values) (1180)

C (graphite) + $2H_2(g) = CH_4(g)$

$\Delta F^0 = -14\ 342 + 11.1T \ln T - 0.0081T^2 + 0.0000006T^3 - 51.74T$ (range 748 to 900°K); between 1470 and 1720°K the average value of I is −48.21; $\Delta H^0_{298.1} = -16\ 963$; $\Delta F^0_{298.1} = -11\ 617$, revised value (1180) *from* (966, 1163); *cf.* (150, 151, 152, 283, 310, 428, 965, 966, 967, 1163); *cf.* $CH_4(g)$

$CO(g) + 3H_2(g) = CH_4(g) + H_2O(g)$ (678, 1065); *cf.* (818.5, 590, 965)

T	1 133.1	1 173.1	1 213.1	1 253.1	1 307.1	1 325.1
log K	−2.37	−2.75	−3.09	−3.45	−4.06	−4.31

$CO_2(g) + 4H_2(g) = CH_4(g) + 2H_2O(g)$

$\Delta F^0 = -35\ 093 + 12.38T \ln T - 0.00415T^2 - 0.00000025T^3 - 39.91T$ (range 570 to 670°K); $\Delta H^0_{298.1} = -38\ 401$; $\Delta F^0_{298.1} = -26\ 339$ (1180); *cf.* (620, 678, 968, 1065, 1120)

T	681.1	709.1	765.1	773.1
K	3.13	2.64	1.69	1.58
Lit*	(968)	(678)	(968)	(678)

* *See also* (252, 408, 965, 1298).

$CH_4.xH_2O(?) = CH_4(g) + xH_2O$ (l) (1469, 1470) (E)

T	P	T	P
273.1	26.5	287.4	123.5
274.2	30.0	289.2	152.0
278.6	47.0	290.4	178.5
281.6	63.5	292.4	232.0
283.0	75.0	293.4*	265.0
283.9	83.0		

* Critical decomposition point at T = 294.6°K.

$CH_3Cl.6H_2O(?) = CH_3Cl(g) + 6H_2O(l)$ (332, 1472, 1473) (E)

T	P	T	P
273.1	0.409	287.45	2.401
273.6	.439	287.6	2.425
274.0	.420	288.0	2.510
275.5	.547	288.6	2.800
277.9	.733	289.3	2.990
279.6	.904	290.6	3.526
281.1	1.059	292.6	4.134
283.6	1.311	293.2	4.618
285.6	1.852	283.5*	4.861

* Critical decomposition point above 294.0°K.

$COCl_2(g)$; $\Delta F^0_{298.1} = -48\ 770$ (885)

$CO(g) + Cl_2(g) = COCl_2(g)$

$\Delta F^0 = -24\ 100 + 4T \ln T + 3.5T$; $\Delta F^0_{298.1} = -16\ 260$ (885) *from* (132, 645); *cf.* (31, 135, 280, 1511)

$CCl_4(l)$

$\Delta H^0_{298.1} = -75\ 700$; $\Delta S^0_{298.1} = -50.84$; $\Delta F^0_{298.1} = -60\ 550$ (833)

$CO(g) + Br_2(g) = COBr_2(g)$

$K = 0.185$ at 346.4°K; $= 0.0475$ at 454.4°K (1447)

$COS(g)$; $\Delta F^0_{298.1} = -39\ 600$ (885)

$CO(g) + \frac{1}{2}S_2(g) = COS(g)$ (885) *from* (874)

$\Delta F^0 = -22\ 500 + 21.0T$; $\Delta F^0_{298.1} = -16\ 230$ (885) *from* (874); *cf.* (1336, 1406, 1407)

T	$\Delta F^0/T$	I
533	−21.39	20.82
575	−18.10	21.03

$CO(g) + S_{\lambda,\mu}(l) = COS(g)$

$K = 435$ at 533°K; 201 at 575°K (874)

C (graphite) + $S_2(g) = CS_2(g)$ (23, 789, 885, 1406, 1407)

CN^-; $\Delta F^0_{298.1} = 39\ 370$ (885)

CNO^-; $\Delta F^0_{298.1} = -23\ 750$ (885)

$HCN(g)$; $\Delta F^0_{298.1} = 28\ 910$ (885); *cf.* (38)

C (graphite) + $\frac{1}{2}N_2(g) + \frac{1}{2}H_2(g) = HCN(g)$

log $K_{2000} = -1.24$ or $\Delta F^0_{2000} = 11\ 300$; $\Delta F^0 = 32\ 000 - 10.3T$ (1497); $\Delta F^0_{298.1} = 28\ 910$ (885); *cf.* (461, 462)

$\mathrm{C + NH_3(g) = H_2(g) + HCN(g)}$

"Very active" charcoal supplied by Fixed Nitrogen Laboratory, Washington, D. C. (38); *cf.* (80, 817, 1475, 1476, 1513)

T	785	793	801	803	807	811
10^6K	3.5	4.9	7.7	3.7	8.6	7.7

$\mathrm{HCN(l)};\ \Delta F^0_{298.1} = 28\ 870$ (885)

$\mathrm{HCN(l) = HCN(g)};\ \Delta F^0_{298.1} = 40$ (885); *cf.* (1129)

$\mathrm{HCN(aq)};\ \Delta F^0_{298.1} = 27\ 510$ (885)

$\mathrm{HCN(aq) = H^+ + CN^-}$

$K_{291.1} = 1.32 \times 10^{-9}$ (1491); $\Delta H = 11\ 000$ (1402); $K_{298.1} = 2.06 \times 10^{-9}$; $\Delta F^0_{298.1} = 11\ 860$ (885); *cf.* (575, 803.1, 885, 1346)

$\mathrm{CN^- + H_2S(aq) = HS^- + HCN(aq)}$ (808)

$\mathrm{HCN(aq) = HCN(g)}$

$K_{298.1} = 0.096$ (871); $\Delta F^0_{298.1} = 1\ 390$ (885); *cf.* (176) *and* Vol. III, p. 365

HCN (in $\mathrm{C_6H_6}$, benzene) $= \mathrm{HCN(aq)}$ (1181); *cf.* Vol. III, p. 422

$\mathrm{HCNO(aq)};\ \Delta F^0_{298.1} = -29\ 100$ (885)

$\mathrm{HCNO(aq) = H^+ + CNO^-}$

$K_{291.1} = 0.00012$ (1047, 1048); $\Delta F^0_{298.1} = 5\ 350$ (885)

$\mathrm{CO(g) + NH_3(g) = CH_3ON(l)}$ (formamide)

$K_{473.1} = 0.0000138$ (994)

$\mathrm{NH_4HCO_3(s) = NH_3(g) + H_2O(g) + CO_2(g)}$ (154, 1071)

$\mathrm{CNI(s)};\ \Delta F^0_{298.1} = 42\ 790$ (885); *cf.* (871)

$\mathrm{I_2(s) + HCN(g) = H^+ + I^- + CNI(s)}$ (871); *cf.* (791, 885, 991.5, 1074); $\Delta F^0_{298.1} = 1\ 520$

p_{HCN}	$m_{(\mathrm{H^+})}$	$m_{(\mathrm{I^-})}$	K
0.00115	0.0161	0.0065	0.091
.00605	.0361	.0144	.086
.00675	.0285	.0118	.049
.00360	.0268	.0100	.075
.00471	.0246	.0106	.055

$\mathrm{CN.NH_2(aq)}$ (cyanamide)

$K_{298.1} = 5.4 \times 10^{-11}$ (745); *cf.* (522)

$\mathrm{CO(NH_2)_2\ (s)}$ (urea); $\Delta F^0_{298.1} = -47\ 280$ (885)

$\mathrm{CO_2(g) + 2NH_3(g) = CO(NH_2)_2(s) + H_2O(g)}$

$K_{298.1} = 0.615$; $\Delta F^0_{298.1} = 290$ (885) *from* (865); *cf.* (418, 962)

$\mathrm{CO(NH_2)_2(aq)};\ \Delta F_{298.1} = -48\ 840$ (885)

$\mathrm{CO(NH_2)_2(aq) = NH_4^+ + CNO^-}$

$\Delta F^0_{298.1} = 6\ 160$ (885) *from* (411, 1492, 1494); $\Delta H = 7\ 500$; $\Delta F^0_{373.1} = 5\ 820$ (229, 1488); for values in $\mathrm{C_2H_6O(l)}$ and $\mathrm{C_2H_6O(aq)}$, *v.* (1260)

T	K	Lit.
334.15	0.000107	(229)
348.31	0.000146	(229)
373.1	0.000391	(411, 1492, 1494)

$\mathrm{CO(NH_2)_2(s) = CO(NH_2)_2(aq)}$;

$\Delta F^0_{298.1} = -1\ 560$ (885) *from* (865)

$\mathrm{CO_2(NH_3)_2(s) = CO_2(g) + 2NH_3(g)}$ (109, 179, 182, 651, 671, 672, 673, 960, 961, 1044)

$\mathrm{NH_2COONH_4(s) = CO(NH_2)_2(s) + H_2O(l)}$ (58, 418)

$\mathrm{NH_2COONH_4(s) + H_2O(g) = (NH_4)_2CO_3(s)}$ (409)

$\mathrm{NH_4SCN(l) = CS(NH_2)_2(l)}$ (thiourea) (29, 228, 421, 1209, 1478, 1483)

$\mathrm{C_2H_2(g)}$

For activity coefficient in aqueous salt solutions at 298.1°K, *v.* (945, 1174)

$\mathrm{C_2H_2(g) = C_2H_2(aq)};\ \Delta F^0_{298.1} = 1\ 878$ *from* (945)

$\mathrm{C_2H_2.6H_2O(?) = C_2H_2(g) + 6H_2O(l)}$ (1471, 1472, 1473) (E)

T	P	T	P
273.1	5.75	282.7	16.4
277.7	9.4	288.1	33.0
280.1	12.0	$\Delta H = 15\ 000$	

$\mathrm{H_2C_2O_4.2H_2O(s) = H_2C_2O_4(s) + 2H_2O(g)}$ (66, 68); *cf.* (844, 1325) (E)

$\Delta H = 6\ 330$ (Thomsen, $\mathrm{H_2O(l)}$)

T	P	T	P
248.1	0.00007*	313.1	0.01025
258.1	.00014*	323.1†	.02053
273.1†	.00045	333.1	.03992*
288.1	.00151	343.1	.07623*
298.1†	.00354		

* Calc. from $\log P = 15.172 - 9661/(T + 250)$.

† From (66); all other values from (68).

$\mathrm{C_2H_4.6H_2O(?) = C_2H_4(g) + 6H_2O(l)}$ (1469, 1470); *cf.* (1472, 1473) (E)

T	P	T	P
273.1	6.5	286.5	28.5
276.1	8.5	287.9	34.5
278.6	11.0	289.7	45.0
281.1	14.0	290.3*	59.0
284.1	21.0	$\Delta H = 15\ 400$	

* Critical decomposition point at $T = 291.8$°K.

$\mathrm{C_2H_4O_2(aq)}$ (acetic acid)

For activity coefficient in aqueous salt solutions, *v.* (1177) *from* (973, 1414)

$\mathrm{C_2H_4O_2(l) = C_2H_4O_2}$ (equilib. vapor)

$\log K = 15\ 000/4.57T - 1.75 \log T - 6.76$ (640, 1059)

$\mathrm{C_2H_6.xH_2O(?) = C_2H_6(g) + xH_2O(l)}$ (E)

$P = 6.0$ at 273.1°K; $= 28.0$ at 285.1°K; critical decomposition point at about 285.1°K (1469, 1470)

$\mathrm{C_2H_5OH(l)};\ \Delta F^0_{298.1} = -45\ 100$ (885) *from* (484, 485)

$\mathrm{C_2H_3ClO_2(aq)}$ (chloroacetic acid)

For activity coefficient in aqueous salt solutions at 298.1°K, *v.* (1177)

$\mathrm{C_2H_3ClO_2(aq) = H^+ + C_2H_2ClO_2^-}$

$\Delta F^0_{298.1} = 3\ 900$ *from* $K_{298.1} = 0.00139$ *from* (1102, 1177, 1344)

$\mathrm{C_2H_3ClO_2(aq) = C_2H_3ClO_2}$ (in *n*-dibutyl ether) (1177, 1178)

$\mathrm{C_2H_2Cl_2O_2(aq)}$ (dichloroacetic acid)

For activity coefficient in aqueous salt solutions at 298.1°K, *v.* (1177)

$\mathrm{C_2H_2Cl_2O_2(aq) = H^+ + C_2HCl_2O_2^-}$

$\Delta F^0_{298.1} = 1\ 716$ from $K_{298.1} = 0.0553$ (1177); $K_{291.1} = 0.0583$ (1177, 1402)

$\mathrm{C_2H_2Cl_2O_2(aq) = C_2H_2Cl_2O_2}$ (in *n*-dibutyl ether) (1177, 1178)

$\mathrm{NH_4C_2H_3O_2(s) = NH_4C_2H_3O_2}$ (equilib. vapor) (acetate)

Vapor density $= 0.20$ g/cm³ at 553°K, $p = 0.153$ atm. (1197)

$\mathrm{(CN)_2(g)}$

$\Delta F^0_{298.1} = 92\ 000$ (885); *cf.* (517, 1047, 1048, 1497)

$\mathrm{x(CN)_2(g) = (CN)_x(s)}$ (1466)

$\mathrm{(CN)_x}$ is not a definite substance (1181)

$\mathrm{2HCN(g) = H_2(g) + (CN)_2(g)}$ (1048)

$\mathrm{2CNI(s) = (CN)_2(g) + I_2(g)}$ (871)

$\Delta H = 41\ 800$ (87.5); $= 48\ 000$ (871); $\Delta F^0 = 32\ 000 - 70T$; $\Delta F^0_{298.1} = 11\ 000$ (885)

T	P	K
363.1	0.0045	2.00×10^{-5}
383.1	.0277	7.76×10^{-4}
389.6	.0436	1.91×10^{-3}
396.1	.0746	5.63×10^{-3}

$(NH_4)_2C_2O_4.H_2O(s) = (NH_4)_2C_2O_4(s) + H_2O(g)$ (E)
At $T = 298.1°K$, $P = 0.0008$ to 0.0024 (916)

$H(CH_3)_2AsO_2(aq) = H^+ + (CH_3)_2AsO_2^-$
$K_{298.1} = 6.4 \times 10^{-7}$ (716)

$(CH_3)_2As(OH)_3(aq) = (CH_3)_2As(OH)_2^+ + OH^-$
$K_{298.1} = 3.8 \times 10^{-13}$ (conductivity) (716); $= 4.05 \times 10^{-13}$ (hydrolysis of chlorohydrate) (716); $= 2.63$, 1.14 and 1.35×10^{-13} (1561); $K_{273.1} = 4.15 \times 10^{-14}$ (hydrolysis of chlorohydrate) (1561)

$C_4H_6O_6.H_2O(s)$ (tartaric acid) $= (?) + xH_2O(g)$ (1113) (E)

T	P	T	P
293.37	0.00738	313.10	0.05664
298.10	.01359	323.10	.10653
302.99	.02393		

$CH_3CONH_2(l) + (CH_3CO)_2O(l) = CH_3CN(l) + 2CH_3COOH(l)$
(796)

$2CH_3COOH(g) = (CH_3COOH)_2(g)$
$\log K = 16\ 480/4.571T - 8.17$ (640, 1059)

$N(CH_3)_4Cl(s) = N(CH_3)_4Cl$ (equilib. vapor)
$\log p = 23\ 649.7/T + 132.316 \log T - 404.1929$ (1371)

$N(CH_3)_4I(s) = N(CH_3)_4I$ (equilib. vapor)
$\log p = 1493.085/T + 24.96449 \log T - 71.5399$ (1371)

$SbC_4H_4O_7^- + 2H^+ = C_4H_4O_6^{--} + Sb^{+++} + H_2O(l)$ (tartrate)
$K_{298.1} = 10^{-11}$ (701)

$C_6H_6(l)$
$\Delta S^0_{298.1} = -51.6$ (867); $\Delta F^0_{298.1} = 27\ 100$ (885)

$C_6H_6(g) + 3H_2(g) = C_6H_{12}(g)$
$K_{539.6} = 5.47$; $K_{553.1} = 1.62$; $\Delta H_{546} = -53\ 260$; (230); *cf.* (358)

$H^+ + C_6H_2(NO_2)_3O^- = C_6H_2(NO_2)_3OH$ (picric acid in benzene)
(885) *from* (1268)

c_W^*	c_B^*	$c_B^{1/2}/c_W$	γ(Picric)
0.0	0.0	15.4	1.00
.00208	.000932	14.9	0.97
.00327	.00225	14.5	.94
.00701	.0101	14.3	.93
.0101	.0199	14.0	.91
.0199	.0700	13.3	.86
.0334	.1772	12.6	.82

*c_W = concn. in water phase; c_B = concn. in C_6H_6 phase.

$C_7H_6O_2(aq)$ (benzoic acid)
Activity coefficient in aqueous salt solutions at 298.1°K (1177) *from* (635, 1254)

$C_7H_6O_2(s) = C_7H_6O_2(aq)$
$\Delta F^0_{298.1} = 2\ 151$ (1177); solubility in aqueous salt solutions at 298.1°K (635, 1177, 1178, 1254)

$C_7H_6O_2(aq) = H^+ + C_7H_5O_2^-$
$K_{298.1} = 6.61 \times 10^{-5}$; $\Delta F^0_{298.1} = 5\ 705$ (1177); *cf.* (1344)

$C_7H_6O_3(aq)$ (salicylic acid)
Activity coefficient in aqueous salt solutions at 298.1°K (1177) *from* (635)

$C_7H_6O_3(aq) = H^+ + C_7H_5O_3^-$
$K_{298.1} = 1.06 \times 10^{-3}$; $\Delta F^0_{298.1} = 4\ 060$ (1177); *cf.* (1344)

$C_7H_6O_3(s) = C_7H_6O_3(aq)$; $\Delta F^0_{298.1} = 2\ 613$ (1177)

$HOC_6H_4COOH(s) = C_6H_5OH(l) + CO_2(g)$
At $T = 476.1°K$, $21 - 28\%$ dissociated (64, 1101)

$C_7H_5NO_3(aq)$ (*o*-nitrobenzaldehyde)
Activity coefficient in aqueous salt solutions at 298.1°K (1176) *from* (503)

$C_7H_5NO_3(s) = C_7H_5NO_3(aq)$; $\Delta F^0_{298.1} = 2\ 476$ (503)

$C_7H_5NO_4(aq)$ (*o*-nitrobenzoic acid)
Activity coefficient in aqueous salt solutions at 298.1°K (1177) *from* (635, 1254)

$C_7H_5NO_4(s) = C_7H_5NO_4(aq)$; $\Delta F^0_{298.1} = 2\ 097$ (1177, 1178, 1254)

$C_7H_5NO_4(aq) = H^+ + C_7H_4NO_4^-$
$K_{298.1} = 6.12 \times 10^{-3}$; $\Delta F^{o}_{298.1} = 3\ 021$ (1177); *cf.* (1344)

$NH_4C_7H_5O_2(s) = NH_4C_7H_5O_2$ (equilib. vapor) (benzoate) (1197)

$C_7H_8N_2S(aq)$ (phenylthiourea)
Activity coefficient in aqueous salt solutions at 293.1°K (1176) *from* (92, 1265)

$C_8H_8O_2(aq)$ (*o*-toluic acid)
Activity coefficient in aqueous salt solutions at 298.1°K (1177) *from* (1265)

$C_8H_8O_2(s) = C_8H_8O_2(aq)$
$\Delta F^0_{298.1} = 2\ 881$ (1177); solubility in $MgSO_4(aq)$ at 298.1°K; (1177, 1265)

$C_8H_8O_2(aq) = H^+ + C_8H_7O_2^-$
$K_{298.1} = 1.30 \times 10^{-4}$; $\Delta F^0_{298.1} = 5\ 304$ (1177); *cf.* (1344)

$C_6H_5NHCOCH_3$ (acetanilide) $+ H^+ + H_2O(l) = C_6H_5NH_3^+ + CH_3COOH(aq)$ (acetic acid)
$K_{373.1} = 950$ (987); *cf.* (321)

$3C_6H_5CHO$ (benzaldehyde) $+ 2NH_3 = (C_6H_5CH)_3N_2$ (hydrobenzamide) $+ 3H_2O$ (344.5)

Ammonium stearate (normal) = Acid + $NH_3(g)$ (E)
At 338.0°K, $P = 0.0367$ (370)

Ammonium arachidate (normal) = Acid + $NH_3(g)$ (E)
At 350.4°K, $P = 0.0532$ (370)

Ammonium salt of humic acid (E) (370)
The ammonia pressure is proportional to the NH_3 content of the substance

$(C_{21}H_{22}N_2O_2)_2.H_2SO_4.6H_2O(s)$ (strychnine sulfate) $= (?) + xH_2O(g)$ (E)
For maximum loss in weight at 298.1°K over H_2SO_4, *v.* (916)

Po, Polonium

$Po(s) = Po^{++} + 2E^-$; $(Po(s), Po^{++})$; $E^0 = -1.0$ (749)

Si, Silicon

$Si(l) = Si(g)$

T	P	ΔH	Lit.
1 800–2 000	1	44 000–49 000	(157)

$Si(s)$; $\Delta H^0, \Delta F^0 = 0$

$SiO_2(l) = Si(g) + O_2(g)$; $P_{O_2} = 10^{-12}$ at 2000°K (157)

$SiO_2(l) = SiO_2(g)$; $P_{2000} = 0.003$ (157)

$HSiO_3^- = H^+ + SiO_3^{--}$ (574)

$H_2SiO_3(aq) = H^+ + HSiO_3^-$ (144, 574, 773)

$2H_2 + Si(s) = SiH_4(g)$ (1499)
$\log K = 8\ 700/4.57T - 1.75 \log T + 2.18$

T	P_{SiH_4}	P_{H_2}	T	P_{SiH_4}	P_{H_2}
453.1	0.0697	1.187	478.1	0.0342	1.116
473.1	0.0500	0.926	533.1	0.0500	1.213

SiF_4 (1499)

$H_2SiF_6 = H^+ + HSiF_6^-$ (568)

$SiCl_4(l)$

$\Delta H^0_{298.1} = -128\ 100$; $\Delta S^0_{298.1} = 48.27$; $\Delta F^0_{298.1} = -113\ 710$ (833)

Ti, Titanium

$Ti(l) = Ti(g)$

T	P	ΔH	Lit.
3 000–4 000	1	77 000–117 000	(157)

$TiO_2(l) = TiO_2(g)$

T	P	ΔH	Lit.
2 000	0.004		
2 500–3 000	1	63 000–77 000	(157)

$Ti^{+++} + H^+ = Ti^{++++} + \frac{1}{2}H_2(g)$ *from* (329)

In HCl(aq) at 298.1°K

$m_{(H^+)}$	$m_{(Cl^-)}$	$m_{(Ti^{++++})}$	$m_{(Ti^{+++})}$	p_{H_2}	μ	K_m
0.9573	0.965	0.0073	0.0062	0.9592	1.048	1.196
.9573	.965	.0072	.0068	.9492	1.047	1.148
.9576	.965	.0074	.0061	.9684	1.048	1.226
1.925	1.930	.0049	.0130	.9605	2.025	0.194
1.925	1.930	.0048	.0131	.9605	2.025	0.186

In H_2SO_4(aq) at 298.1°K

$m_{(H^+)}$	$m_{(SO_4^{--})}$	$m_{(Ti^{++++})}$	$m_{(Ti^{+++})}$	p_{H_2}	μ	K_m
0.9604	0.4825	0.0048	0.0091	0.9643	1.524	0.536
.9270	.4660	.0077	.0147	.9648	1.523	.548
.9604	.4825	.0047	.0091	.9671	1.524	.534
.9270	.4660	.0077	.0146	.9671	1.523	.559
.9896	.4911	.0033	.0061	.9389	1.531	.520
.9896	.4911	.0033	.0061	.9389	1.531	.518
.9896	.4911	.0033	.0060	.9406	1.531	.542
.9882	.4902	.0035	.0063	.9444	1.531	.548
.9899	.4911	.0031	.0063	.9617	1.530	.486
.9566	.4828	.0049	.0091	.9683	1.523	.551
.9569	.4825	.0049	.0090	.9683	1.523	.558
.9839	.4937	.0031	.0049	.6889	1.526	.553
.9835	.4937	.0035	.0045	.5175	1.527	.563
.9924	.4982	.0031	.0026	.3541	1.529	.693
.9982	.5007	.0027	.0017	.2446	1.529	.778
.9789	.4909	.0037	.0058	.8095	1.527	.523

In H_2SO_4(aq) at 308.1°K

$m(H^+)$	% Ti as Ti^{++++}	p_{H_2}	K_m
0.9590	42.2	0.9408	0.740
.9590	42.8	.9408	.757
.9590	41.9	.9408	.730
.9590	41.8	.9408	.726
.9590	41.8	.9408	.726

In H_2SO_4(aq) at 318.1°K

$m(H^+)$	% Ti as Ti^{++++}	p_{H_2}	K_m
0.9569	49.3	0.9342	0.982
.9573	49.8	.9461	1.008
.9569	49.8	.9461	1.008
.9573	49.9	.9474	1.013
.9573	49.4	.9487	0.993
.9573	49.6	.9487	1.001

$TiO_2(l) = Ti(g) + O_2(g)$; $P_{O_2} = 10^{-18}$ at 2000°K (157)

$TiCl_4(l)$; $S^0_{298.1} = 59.51$; $\Delta S^0_{298.1} = -47.09$ (833)

$TiCl_4(g) + H_2(g) = TiCl_3(s) + HCl(g)$ (499)

Ge, Germanium

$GeH_4(g) = Ge(s) + 2H_2(g)$ (1028)

Zr, Zirconium

$Zr(l) = Zr(g)$

T	P	ΔH	Lit.
2 500–3 000	1	63 000–77 000	(157)

$ZrO_2(l) = Zr(g) + O_2(g)$; $P_{O_2} = 0.6$ at 3000°K (157)

$ZrO_2(s) = Zr(g) + O_2(g)$; $P_{O_2} = 10^{-11}$ at 2000°K (157)

$ZrO_2(l) = ZrO_2(g)$

T	P	ΔH	Lit.
2 000	0.068		(157)
3 000	0.021		
3 500–4 000	1	92 000–117 000	

$Zr(NO_3)_4.5H_2O(s) = (?) + xH_2O(g)$ (E)

For maximum loss in weight at 298.1°K over H_2SO_4, *v.* (916)

Sn, Tin

Sn (white); ΔH^0, $\Delta F^0 = 0$ (885)

Sn (white) = Sn (gray)

$\Delta H^0_{273.1} = 532$; $\Delta F^0 = 666 + 0.49T \ln T - 4.78T$; $\Delta S^0_{298.1} = -1.94$; $\Delta F^0_{298.1} = 9.5$; (197, 198); *cf.* (290–294, 300, 885, 988, 989)

Sn^{++}; $E^0_{298.1} = 0.136$; $\Delta F^0_{298.1} = -3\ 138$ (885)

$SnO(s) + H_2(g) = Sn(l) + H_2O(g)$

$K = 7.90$ at 1073.1°K; $= 10.35$ at 1173.1°K (1538)

$SnO(s) + C(s) = Sn(l) + CO(g)$; $P_{1023} = 1$ (1363, 1364)

$Sn(l) + 2H_2O(g) = SnO_2(s) + 2H_2(g)$ (362); *cf.* (1538)

T	K	T	K	T	K
928	0.434	1044	0.240	1099	0.203
931	.377	1046	.240	1099	.193
971	.359	1082	.191	1169	.152
976	.333				

$Sn(l) + 2CO_2(g) = SnO_2(s) + 2CO(g)$ (362); *cf.* (933)

T	918	939	954	977	1 045	1 088
K	0.326	0.312	0.304	0.295	0.270	0.255

$Sn^{++++} + 4H_2O = Sn(OH)_4(s) + 4H^+$ (303)

$SnCl_2.4NH_3(s) = SnCl_2(s) + 4NH_3(g)$ (99) (E)

T	237.1	273.1	283.7	ΔH
P	0.0229	0.424	0.757	37 200

$SnCl_2.9NH_3(s) = SnCl_2.4NH_3(s) + 5NH_3(g)$ (99) (E)

T	194.6	224.1	237.6	ΔH
P	0.0091	0.188	0.478	38 000

$SnCl_4(l)$

$\Delta H^0_{298.1} = -128\ 010$; $\Delta S^0_{298.1} = -49.66$; $\Delta F^0_{298.1} = -113\ 210$ (833)

$SnBr_2.2NH_3(s) = SnBr_2(s) + 2NH_3(g)$ (99) (E)

T	353.1	370.1	383.6	ΔH
P	0.039	0.105	0.211	27 200

$SnBr_2.3NH_3(s) = SnBr_2.2NH_3(s) + NH_3(g)$ (99) (E)

T	329.0	334.1	337.7	ΔH
P	0.0463	0.088	0.121	12 400

$SnBr_2.5NH_3(s) = SnBr_2.3NH_3(s) + 2NH_3(g)$ (99) (E)

T	251.8	273.1	290.7	ΔH
P	0.017	0.1756	0.466	19 600

$SnBr_2.9NH_3(s) = SnBr_2.5NH_3(s) + 4NH_3(g)$ (99) (E)

T	194.6	225.6	233.4	ΔH
P	0.018	0.2703	0.457	30 200

$SnI_2.NH_3(s) = SnI_2(s) + NH_3(g)$ (99) (E)

T	370.1	388.1	412.1	ΔH
P	0.0084	0.0108	0.066	16 000

$SnI_2.2NH_3(s) = SnI_2.NH_3(s) + NH_3(g)$ (99) (E)

T	334.1	353.1	370.1	ΔH
P	0.025	0.063	0.153	13 300

$SnI_2.3NH_3(s) = SnI_2.2NH_3(s) + NH_3(g)$ (99) (E)

T	307.9	334.1	353.1	ΔH
P	0.028	0.196	0.503	11 900

$SnI_2.5NH_3(s) = SnI_2.3NH_3(s) + 2NH_3(g)$ (99) (E)

T	250.1	273.1	289.6	ΔH
P	0.0110	0.078	0.220	20 400

$SnI_2.(9?)NH_3(s) = SnI_2.5NH_3(s) + 4NH_3(g)$ (99) (E)

T	194.6	217.1	227.1	ΔH
P	0.0067	0.074	0.155	31 600

Pb, Lead

$Pb(g)$

$C_p = 4.97$; $\Delta F^0 = 51\,091 + 0.36T \ln T + 0.00176T^2 - 33.86T$; $\Delta F^0_{298.1} = 41\,764$ (1189)

$Pb(l)$

$\Delta F^0 = 401 - 2.34T \ln T + 0.00176T^2 + 13.25T$; $\Delta F^0_{298.1} = 533$ (1189); $\Delta F^0_{600.5} = 0$; $C_p = 7.67$ (1484); *cf.* (663, 765)

$Pb(l) = Pb(g)$

$\Delta F^0 = 50\,690 + 2.70T \ln T - 47.108T$; $\Delta F^0_{298.1} = 41\,231$ (1189) *from* (369, 510, 511, 512, 586, 664, 1233, 1234, 1274, 1500, 1501)

$Pb(s)$ (1189); $\Delta F^0 = 0$; $\Delta H^0 = 0$; $C_p = 5.33 + 0.00352t$

$Pb(s) = Pb$ (in het. amalg.); $E = 0.00552 + 0.0000137t$; $E_{298.1} = 0.00586$; $\Delta F^0_{298.1} = -270$ (1189) *from* (256, 470); *cf.* (37, 188, 189, 193)

$Pb(s) = Pb$ (in amalg., $x_2 = 0.00697$); $E_{298.1} = 0.0140$; $\Delta F^0_{298.1} = -646$ (1189) *from* (37, 188, 189, 862, 1220, 1395); $E = 0.0051 + 0.000233t$; $E_{298.1} = 0.0109$ (188, 189)

Pb^{++}

$E^0_{298.1} = 0.122$; $\Delta F^0_{298.1} = -5\,630$ (885). (Revised value) *from* (188, 189, 470, 477, 478, 598, 862); *cf.* (701); $E^0_{298.1} = 0.1203$; $\Delta F^0_{298.1} = -5\,551$ (1173)

$Sn(s) + Pb^{++} = Pb(s) + Sn^{++}$

In $SnClO_4$ and $PbClO_4$ at 298.1°K (1089); *cf.* (885, 1283, 1284)

$\mu^{1/2}$	0.39	0.43	0.52	0.55
K	3.124 ± 0.034	2.979 ± 0.021	3.005 ± 0.020	2.956 ± 0.024

PbO (red)

$\Delta F^0_{298.1} = -45\,050$ (1381); *cf.* (954); *see* Ishikawa and Shibata (674); if these authors used PbO(y), then $\Delta F^0_{298.1} = -45\,081$

$Pb(s) + H_2O(l) = H_2(g) + PbO$ (red)

$E^0_{298.1} = -0.2494$; $\Delta F^0_{298.1} = 11\,510$ (1381)

Pb (in het. amalg.) $+ H_2O(l) = H_2(g) + PbO$ (red?)

$E^0 = -0.2579 + 0.000375\,(t - 25) - 0.0000035\,(t - 25)^2$; $\Delta F^0_{298.1} = 11\,902$ (674)

PbO (yellow)

$C_p = 11.57$ (887); $= 11.25 + 0.0016T$ (1189.1) *from* (785, 786, 934, 1056, 1198, 1281); $\Delta F^0_{298.1} = -44\,896$ (1189.1)

PbO (red) $= PbO$ (yellow)

$\Delta F^0_{298.1} = 160$ (1189.1); *cf.* (22, 495, 1272)

$PbO.\frac{1}{3}H_2O(s)$; $\Delta F^0_{298.1} = -63\,520$ (1189.1)

$PbO_2(s)$

$\Delta F^0_{298.1} = -52\,070$ (1189.1); *see also* $PbCl_2(s) + 2H_2O(l) + Cl_2(g)$

$PbO_2(s) = PbO_x(s) + \frac{1}{2}(2 - x)O_2(g)$ (1002, 1205)

$PbO_2(s) + H_2(g) = PbO$ (yellow?) $+ H_2O$ (in NaOH, $1N$)

$E^0_{290.1} = 1.078$ (495, 496, 497)

$PbOH^+$; $\Delta F^0_{298.1} = -53\,440$ (1189.1)

$HPbO_2^-$; $\Delta F^0_{298.1} = -80\,602$(1189.1)

PbO (red) $+ OH^- = HPbO_2^-$

$K_{298.1} = 0.0402$; $\Delta F^0_{298.1} = 1\,903$ (1189.1); *cf.* (22, 45, 83, 450, 494, 1025, 1207, 1272); for solubility in KOH solns., *v.* (1189.1

PbO (yellow) $+ OH^- = HPbO_2^-$

$K_{298.1} = 0.0531$; $\Delta F^0_{298.1} = 1\,740$ (1189.1); for solubility in KOH solns., *v.* (1189.1)

$PbO.\frac{1}{3}H_2O(s) + OH^- = HPbO_2^- + \frac{1}{3}H_2O(l)$

$K_{298.1} = 0.0780$; $\Delta F^0_{298.1} = 1\,512$ (1189.1); *cf.* (494, 1269, 1551); for solubility in KOH solns., *v.* (1189.1)

$Pb(OH)_2(aq)$; $\Delta F^0_{298.1} = -96\,888$ (1189.1)

$PbO.\frac{1}{3}H_2O(s) + \frac{2}{3}H_2O(l) = Pb(OH)_2\,(aq)$

$K_{291.1} = 0.00045$ (1147)

$Pb(OH)_2(aq) = PbOH^+ + OH^-$

$K_{291.1} = 4 \times 10^{-5}$ (1147); $\Delta H = 1\,000$; $K_{298.1} = 4.2 \times 10^{-5}$; $\Delta F^0_{298.1} = 5\,980$ (1189.1)

$Pb(OH)_2(aq) = H^+ + HPbO_2^-$

$K_{291.1} = 1.47 \times 10^{-12}$ (estimated); $K_{298.1} = 1.2 \times 10^{-12}$; $\Delta H = 6\,000$; $\Delta F^0_{298.1} = 16\,260$ (1189.1); *cf.* (83)

$PbCl_2(l) + H_2(g) = Pb(l) + 2HCl(g)$ (40, 1109)

$Sn(l) + PbCl_2(l) = Pb(l) + SnCl_2(l)$ (912)

$PbCl_2(s)$

$E^0_{298.1} = 1.6264$; $\Delta F^0_{298.1} = -75\,056 \pm 10$ (1189) *from* (256, 470); *cf.* (14, 193, 530, 792)

$PbCl_2(s) + 2H_2O(l) + Cl_2(g) = PbO_2(s) + 4HCl(aq)$

$K_{298.1} = 2.8 \times 10^{-8}$ (1518); $K_{298.1} = 3.22 \times 10^{-9}$; $\Delta F^0_{298.1} = 11\,590$ (1189) (gives for PbO_2, *q.v.*, $\Delta F^0_{298.1} = -51\,118$)

$PbCl_2.xNH_3 = (?) + xNH_3(g)$ (E)

The large degree of supersaturation of the solid solutions reduces the pressure according to (380) and hence values of (98) are uncertain

$PbCl_2.NH_3(s) = PbCl_2(s) + NH_3(g)$ (98) (E)

T	P	T	P
351.56	0.0174	372.7	0.220
353.24	0.024	$\Delta H = 13\,300$	

$PbCl_2.1\frac{1}{2}NH_3(s) = PbCl_2.NH_3(s) + \frac{1}{2}NH_3(g)$ (98) (E)

$\Delta H = 11\,300$; Ephraim (380) observed an intermediate stage in the decomposition

T	P	T	P
294.8	0.021	319.1	0.351

$PbCl_2.2NH_3(s) = (?) + xNH_3(g)$ (98, 380) (E)

$\Delta H = 12\,400x$ (380); $= 11\,000x$ (98)

T	P	T	P
293.6*	0.0432	341.6	0.768
307.75*	.1849	344.6	.816
319.2*	.455	345.1	.829
324.1	.345	345.6	.941
332.6	.487	353.1	1.026
333.1	.529		

* From (98); all other values from (380).

$PbCl_2.3\frac{1}{4}NH_3(s) = PbCl_2.2NH_3(s) + 1\frac{1}{4}NH_3(g)$ (98) (E)

T	P	T	P
251.9	0.0449	273.1	0.474
262.0	0.1489	$\Delta H = 11\,750$	

$PbCl_2.8NH_3(s) = PbCl_2.3\frac{1}{4}NH_3(s) + 4\frac{3}{4}NH_3(g)$ (98) (E)

T	P	T	P
194.6	0.0024	251.9	0.445
223.1	0.0350	$\Delta H = 38\,950$	

$PbCl_5^-$; $\Delta F^0_{298.1} = -104\,700$ (1189)

$PbCl_2(s) + Cl_2(g) + Cl^- = PbCl_5^-$

$K_{298.1} = 0.055$ (1518); $\Delta F^0_{298.1} = -31\ 367$ (1189)

$HPbCl_5(aq)$; $\Delta F^0_{298.1} = -104\ 700$ (1189)

$PbBr_2(s)$

$E^0_{298.1} = 1.3449$; $\Delta F^0_{298.1} = -62\ 063 \pm 20$ (1189) *from* (470, 1173); *cf.* (168, 473, 792, 834)

Pb (in het. amalg.) + $Br_2(l) = PbBr_2(s)$; $E_{298.1} = 1.4343$ (473)

$PbBr_2.NH_3(s) = PbBr_2(s) + NH_3(g)$ (98) (E)

T	P	T	P
383.7	0.0220	429.7	0.2009
412.5	0.1012	457.45	0.604
	$\Delta H = 15\ 600$		

$PbBr_2.2NH_3(s) = PbBr_2.NH_3(s) + NH_3(g)$ (380) (E)

T	P*	T	P*
272.1	0.059	326.6	0.599
295.1	.176	333.1	.738
305.1	.276	335.1	.789
315.1	.393	339.6	.897
325.1	.566	343.1	.995
	$\Delta H = 12\ 100$		

* Ephraim observes various degrees of supersaturation. In such cases the lower pressure values which Biltz and Fischer (98) observed for the compound are given.

$PbBr_2.3NH_3(s) = PbBr_2.2NH_3(s) + NH_3(g)$ (98) (E)

T	P	T	P
244.4	0.0372	291.6	0.784
273.1	0.2480	$\Delta H = 9\ 500$	

$PbBr_2.5\frac{1}{2}NH_3(s) = PbBr_2.3NH_3(s) + 2\frac{1}{2}NH_3(g)$ (98) (E)

T	P	T	P
228.1	0.022	273.1	0.568
245.1	0.0946	$\Delta H = 22\ 500$	

$PbBr_2.8NH_3(s) = PbBr_2.5\frac{1}{2}NH_3(s) + 2\frac{1}{2}NH_3(g)$ (98) (E)

T	P	T	P
221.1	0.036	262.2	0.921
243.7	0.266	$\Delta H = 20\ 500$	

$PbI_2(s)$

$E^0_{298.1} = 0.89949$; $\Delta F^0_{298.1} = -41\ 510 \pm 5$ (470); *cf.* (789.5)

$Pb(s) + I_2(s) = PbI_2(s)$

$E_{298.1} = 0.8983$ in $0.5N$ KI; $= 0.8968$ in $0.1N$ KI (789.5); $= 0.89949$; $E_{273.1} = 0.90012$ (470)

Pb (in het. amalg.) + $I_2(s) = PbI_2(s)$

$E_{298.1} = 0.89363$; $E_{273.1} = 0.89460$ (470)

Pb (amalg. $x_2 = 0.000697$) + $I_2(s) = PbI_2(s)$

$E_{298.1} = 0.8843$ in $0.5N$ KI (interpolated); $= 0.8828$ in $0.1N$ KI (interpolated) (789.5)

$PbI_2.\frac{1}{2}NH_3(s) = PbI_2(s) + \frac{1}{2}NH_3(g)$ (98) (E)

T	P	T	P
383.7	0.0636	429.7	0.4756
388.0	0.0840	$\Delta H = 7\ 200$	

$PbI_2.NH_3(s) = PbI_2.\frac{1}{2}NH_3(s) + \frac{1}{2}NH_3(g)$ (98) (E)

T	P	T	P
329.0	0.014	384.1	0.398
353.3	0.093	$\Delta H = 6\ 600$	

$PbI_2.2NH_3(s) = PbI_2.NH_3(s) + NH_3(g)$ (98) (E)

T	P	T	P
289.6	0.0180	329.0	0.417
307.55	0.1470	$\Delta H = 11\ 300$	

$PbI_2.5NH_3(s) = PbI_2.2NH_3(s) + 3NH_3(g)$ (98, 380) (E)

T	P	T	P
242.2	0.0129	289.6	0.5099
258.1	.053	290.2	.530
270.1	.132*	291.6	.546
270.1	.136	295.1	.651
273.1	.161	300.1	.825
286.1	.408	303.6	.938
First decomposition product (380)			
315.6	0.164	343.1	0.658
320.1	.211	351.1	.893
329.1	.362	354.1	.980
330.6	.382		
Second decomposition product (380)			
356.1	0.084	399.6	0.605
373.6	.184	408.6	.804
388.6	.378		

* Interpolated value from (98); all others from (380). The yellow $PbI_2.5NH_3$ of Biltz and Fischer (98) is very likely identical with the white $PbI_2.4NH_3$ of Ephraim (380). Biltz and Fischer studied the decomposition; Ephraim the synthesis.

$PbI_2.8NH_3(s) = PbI_2.5NH_3(s) + 3NH_3(g)$ (98) (E)

T	P	T	P
194.6	0.0079	239.1	0.557
216.6	.0852	$\Delta H = 23\ 400$	

$Pb(IO_3)_2(s) = Pb^{++} + 2IO_3^-$

$K_{298.1} = 5.92 \times 10^{-12}$; $\Delta F^0_{298.1} = 16\ 690$

$PbS(s)$

$\Delta F^0_{298.1} = 18\ 000$ (1189) *from* (615); $C_p = 12.20$ (887); *cf.* (363)

$PbS(s) = Pb(l) + S$ (equilib. gas)

$P_{961} = 0.0026$ (1307); *cf.* (456)

$PbS(s) + 2PbO(s) = 3Pb(l) + SO_2(g)$ (1201, 1202, 1203, 1308, 1311, 1312, 1313, 1314)

$PbS(s) + H_2S(g) = Pb^{++} + 2HS^-$

$\log K_{298.1} = -18.88$; $\Delta F^0_{298.1} = 25\,770$ (1189) *from* (615)

$PbSO_4(s)$

$\Delta F^0_{298.1} = -176\ 500$ (1189); $C_p = 25.07$ (786)

$Pb(s) + PbO_2(s) + 2H_2SO_4(aq) = 2PbSO_4(s) + 2H_2O(l)$

$E^0_{298.1} = 2.021$ (347); $\Delta F^0_{298.1} = -93\ 270$ (366)

$m_{(H_2SO_4)}$	$\gamma_{(H_2SO_4)}$	$a_{(H_2O)}$	E(366)	E(347)	$\Delta F^0_{298.1}$
2.687	0.158	0.879	1.994	1.953	2.021
2.541	.155	.888	1.988	1.947	2.021
0.4961	.178	.982	1.866	1.828	2.053
0.05306	.388	.998	1.735	1.727	2.024

$PbI_2(s) + SO_4^{--} = PbSO_4(s) + 2I^-$ (420)

$K_{298.1} = 0.62$ (approx.); $\Delta F^0_{298.1} = 892$; solubility at 298.1°K

$c_{(Na_2SO_4)}$	$c_{(NaI)}$	μ_c	K_c
0.00182	0.02288	0.0283	0.5742
.00214	.02520	.0316	.5932
.00564	.04158	.0585	.6136
.00577	.04151	.0588	.5968
.0089	.0523	.0790	.6140
.0090	.0521	.0791	.6042
.00946	.05275	.0811	.5870
.00940	.05265	.0809	.5896
.0178	.0684	.1218	.5256
.0177	.0687	.1218	.5342
.0406	.0968	.2186	.4616
.04101	.1009	.2239	.4420
.04116	.1008	.2243	.4400

$PbS(s) + PbSO_4(s) = 2Pb(l) + 2SO_2(g)$

$\Delta H_{298.1} = 96\,550$ (by combination of calorimetric data); $= 95\,230$ (by addition of ΔH's obtained by slopes of two other equations); $\Delta F^0_{298.1} = 67\,900$ (by addition); $= 71\,650$ (by use of entropies) (887) *from* (636, 1201, 1202, 1203, 1308, 1311, 1312, 1313)

$PbCO_3(s)$

$C_p = 25.95$ (785, 786); $\Delta F^0_{298.1} = -149\,000$ (1189.1) *from* (306, 307)

$PbCO_3(s) = PbO$ (yellow) $+ CO_2(g)$

$\Delta F^0 = 21\,140 + 7.38T \ln T - 0.00355T^2 + 0.00000031T^3 - 81.82T$ (range 457 to 558°K), from $\Delta H_{290.1} = 19\,280$; graph gives $\Delta H = 20\,700$; $\Delta F^0_{298.1} = 8\,970$ (1189.1) *from* (306, 307). $\Delta H = 24\,830$; $\Delta F^0_{298.1} = 11\,380$ (274)

$PbCl_2(s) + CO_3^{--} = PbCO_3(s) + 2Cl^-$

$T = 298.1$°K *from* (609, 610)

$c_{(NaCl)}$	$c_{(Na_2CO_3)}$	μ_c	K_c
2.277	0.00635	2.283	817
3.674	.01325	3.687	1 020

$PbBr_2(s) + CO_3^{--} = PbCO_3(s) + 2Br^-$

$T = 298.1$°K *from* (609, 610)

$c_{(NaBr)}$	$c_{(Na_2CO_3)}$	μ_c	K_c
1.682	0.0100	1.692	283
2.262	.0138	2.274	371

$PbSO_4(s) + CO_3^{--} = PbCO_3(s) + SO_4^{--}$

$T = 298.1$°K *from* (609, 610)

$c_{(Na_2SO_4)}$	$c_{(Na_2CO_3)}$	μ_c	K_c
0.2103	0.0025	0.6384	84.2
.4213	.00425	1.277	99.2
.6319	.00635	1.915	99.6
.8425	.0085	2.554	99.2

$PbSO_4(s) + 2HCO_3^- = PbCO_3(s) + SO_4^{--} + H_2CO_3$ (aq)

$K_{291.1} = 29.74$; $\Delta F^0_{291.1} = -2\,010$; $\Delta H = -10\,000$; $\Delta F^0_{298.1} = -1\,820$ (1189) *from* (36)

$c_{(SO_4^{--})}$	$c_{(HCO_3^-)}$	$c_{(H_2CO_3)}$	μ_c	$K_{c291\cdot1}$
0.0461	0.0061	0.0451	0.145	28.43
.0468	.0061	.0449	.147	28.87
.0476	.0036	.0164	.196	30.82
.0473	.0055	.0378	.147	30.30

$Pb(CH_3CO_2)_2.3H_2O(s) = Pb(CH_3CO_2)_2(s) + 3H_2O(g)$ (1032) (E)

For the salt which resulted from the anhydrous salt through absorption of water from the air:

T	Rel. P*	T	Rel. P*
288.1	0.00043	294.5	0.00050
291.7	.00047	294.6	.00051
293.5	.00047		

For the salt crystallized out of solution. The pressure decrease becomes greater after the loss of 2 moles of water. At ½ mole of water, the pressure becomes a minimum:

T	Rel. P*	T	Rel. P*
288.0	0.00059	294.0	0.00050
291.7	0.00056	294.5	.00056

* "Relative pressure;" *i.e.*, the ratio of the loss in weight of the salt to the loss in weight of pure water.

$PbSO_4.PbO(s)$; $C_p = 36.64$ (887)

$3PbS(s) + 2(PbO.PbSO_4)(s) = 7Pb(l) + 5SO_2(g)$

$\Delta F^0 = 267\,970 + 30.7T \ln T - 0.0177T^2 + 0.00000155T^3 - 435.5T$ (range 985 to 1063°K); $\Delta F^0_{298.1} = 188\,757$ (887) *from* (1201, 1202, 1203)

$PbS(s) + 7PbSO_4(s) = 4(PbSO_4.PbO)(s) + 4SO_2(g)$

$\Delta F^0 = 157\,907 + 13.13T \ln T - 0.0142T^2 + 0.00000124T^3 - 235.6T$ (range 855 to 961°K); $\Delta F^0_{298.1} = 97\,684$ (887) *from* (636, 1203, 1307, 1311, 1312, 1313, 1314)

$NH_4Cl.2PbCl_2(s)$

$\Delta F^0_{298.1} = -200\,740$ (1189)

$NH_4Cl(s) + 2PbCl_2(s) = NH_4Cl.2PbCl_2(s)$

$E^0_{298.1} = 0.0307$; $\Delta F^0_{298.1} = -2\,834$; $\Delta F^0_{291.1} = -2\,815$; $\Delta F^0_{373.1} = -3\,195$ (193)

$2PbCO_3(s) = PbO.PbCO_3(s) + CO_2(g)$

$\Delta F^0 = 17\,000 + 16.99T \ln T - 0.00355T^2 + 0.00000031T^3 - 74.96T$ (range 489 to 541°K); $\Delta F^0_{298.1} = 6\,883$ (1189) *from* (274); *cf.* (275)

$Pb_3O_4(s)$

$C_p = 35.70 + 0.0095T$ (1189) *from* (1006, 1106, 1281); $\Delta F^0_{298\,1} = -147\,342$ (1189)

$Pb_3O_4(s) = 3PbO$ (yellow) $+ \frac{1}{2}O_2(g)$

$\Delta F^0 = 19\,179 - 1.30T \ln T + 0.0021T^2 - 15.109T$ (range 718 to 880°K); $\Delta F^0_{298.1} = 12\,654$ (1189) *from* (1205); *cf.* (495, 496, 497, 998–1001, 1006)

$3PbO_2(s) + 2H_2(g) = Pb_3O_4(s) + 2H_2O$ (in NaOH, 1N)

$E_{290\cdot1} = 1.135$ (495, 496, 487)

$3(PbO.PbCO_3)(s) = 2(PbCO_3.2PbO)(s) + CO_2(g)$

$\Delta F^0 = 45\,000 + 16.99T \ln T - 0.00355T^2 + 0.00000031T^3 - 119.0T$ (range 541 to 614°K); $\Delta F^0_{298.1} = 21\,750$ (1189.1) *from* (274)

$PbCO_3.2PbO(s) = 3PbO$ (yellow) $+ CO_2(g)$

$\Delta F^0 = 25\,700 + 16.99T \ln T - 0.00355T^2 + 0.00000031T^3 - 83.80T$ (range 611 to 678°K); $\Delta F^0_{298.1} = 12\,946$ (1189.1) *from* (274)

$Pb_3(CO_3)_2(OH)_2(s)$; $\Delta F^0_{298.1} = -407\,700$ (1189)

$Pb_3(CO_3)_2.(OH)_2(s) + 4H_2CO_3(aq) = 3Pb^{++} + 6HCO_3^- + 2H_2O(l)$

log $p.f._{291.1} = 2.5$; $\Delta F^0_{291.1} = 30\,020$; $\Delta H = -23\,160$; $\Delta F^0_{298.1} = 31\,330$ (1191) *from* (1147); *cf.* (564)

$m_{(Pb)}$	$m_{(H_2CO_3)}$	$(\log 1/K_m{}^{1/9})$	$\mu^{1/2}$
0.000008	(?)		
.000029	0.000064	3.0325	0.009
.000034	.000123	2.5991	.010
.000040	.000328	2.7193	.011
.000048	.000592	2.7627	.012
.000053	.000988	2.7825	.013
.000076	.002400	2.7541	.015

$Pb_3(CO_3)_2(OH)_2(s) + 7OH^- = 3HPbO_2^- + 2CO_3^{--} + 3H_2O(l)$

$K_{298.1} = 8 \times 10^{-6}$; $\Delta F^0_{298.1} = 6\,961$ (1189.1); *cf.* (1147)

$Pb_3(CO_3)_2(OH)_2(s) + 2HCO_3^- = 3PbCO_3(s) + CO_3^{--} + 2H_2O(l)$

Approx. log $K_{291.1} = 1.50$; $\Delta H = -18\,000$; $K_{298.1} = 15.1$; $\Delta F^0_{298.1} = -1\,610$ (1189.1) *from* (36)

Th, Thorium

$Th(l) = Th(g)$ (157)

T	P	ΔH
2 000–2 500	1	49 000–63 000

$ThO_2(?) = ThO_2(g)$ (157)

T	P	ΔH
2 000	0.0_54	
3 000	0.021	
3 500–3 800	1	91 000–100 000

$ThO_2(?) = Th(g) + O_2(g)$ (157)

T	P_{O_2}	T	P_{O_2}
2 000	10^{-27}	3 000	0.0_56

$ThCl_4.18NH_3(s) = ThCl_4.12NH_3(s) + 6NH_3(g)$ (278) (E)

T	P	T	P
250.6	0.324	273.1	1.356
263.1	0.737	281.1	2.145
	$\Delta H = 52\ 980$		

$Th(SO_4)_2.8H_2O = Th^{++++} + 2SO_4^{--} + 8H_2O(l)$; *v.* $SO_4^{--}Th^{++++}$, Vol. IV, p. 336

$Th(SO_4)_2.9H_2O(s) = (?) + xH_2O(g)$ (E)

Maximum loss in weight at 298.1°K over H_2SO_4 (916); for the reaction, $Th(SO_4)_2.8H_2O = Th(SO_4)_2.4H_2O + 4H_2O$, Koppel (787) gives $\log P' = \log P - 3381/4.606T + 2.3286$. $P = 0.04154$ at $T = 303.1$°K and $P = 0.08044$ at $T = 315.1$°K

$Th(C_2O_4)_2.6H_2O(s) = (?) + xH_2O(g)$ (E)

Maximum loss in weight at 298.1°K over H_2SO_4 (916). The water is lost continuously at first, then suddenly at the change to dihydrate. This change to the dihydrate is the same for the crystalline and microcrystalline form, whence the two forms are identical (594)

Tl, Thallium

$Tl(\beta)$; $\Delta F^0 = 94 - 0.198T$; $\Delta F^0_{298.1} = 35$

$Tl(l)$

$\Delta F^0 = 389 - 1.85T \ln T + 10.940T$; $\Delta F^0_{298.1} = 468$; $\Delta H^0_{298.1} = 900$

$Tl(l) = Tl(g)$ (482, 1500, 1501)

$Tl(s)$(elect. crystals); ΔH^0, $\Delta F^0 = 0$ (470, 1221)

$Tl(\alpha)$; $\Delta F^0_{298.1} = -4$

$Tl(\beta) = Tl(l)$

$\Delta F = 255 - 1.85T \ln T + 11.138T$; $\Delta F^0_{298.1} = 433$; $\Delta H^0_{298.1} = 551$; $\Delta F^0_{376.6} = 0$ (1223); $\Delta H_{576.6} = 1\ 470$ (1230)

$Tl(\alpha) = Tl(\beta)$

$\Delta F^0 = 39 - 1.85T$; $\Delta F^0_{298.1} = 39$; $\Delta F^0_{508.4} = 0$ (1223)

Tl (in het. amalg.)

$C_p = 8.3$ (883, 885); $\Delta F = -614 - 1.95T \ln T + 12.985T$; $\Delta F_{298.1} = -55$; $\Delta H_{298.1} = -33$ (470)

$Tl(\alpha)$ = Tl (in het. amalg.)

$E_{291.1} = 0.00208$; $E_{298.1} = 0.0022$ (1223); $= 0.0026$ (1218); $= 0.0028$ (732); $= 0.0027$; $dE/dt = 0.000020$ (470). $\Delta F^0 = -614 - 1.95T \ln T + 12.998T$; $\Delta F_{298.1} = -51$; $\Delta H_{298.1} = -33$ (470).

$Tl(\beta)$ = Tl (in het. amalg.)

$\Delta F = -708 - 1.95T \ln T + 13.183T$; $\Delta F_{298.1} = -90$; $\Delta H_{298.1} = -127$; $E_{291.1} = 0.0038$ *from* (1223)

Tl (amalg., $x = 1$)

$\Delta F^0 = -1\ 897 - 3.85T \ln T + 25.760T$; $\Delta F^0_{298.1} = -757$; $\Delta H^0_{298.1} = -749$

x_{Tl}	x_{Tl}/x_{Hg}	$(a/x)_{Tl(293.1)}$ (885)	$(a/x)_{Hg(293.1)}$
0	0	1	1
0.005	0.00502	1.06	0.9998
0.01	0.0101	1.15	0.999
0.05	0.0526	1.80	0.986
0.1	0.111	2.84	0.950
0.2	0.250	4.98	0.866
0.3	0.428	6.60	0.790
0.4	0.667	7.57	0.734
0.5	1.000	7.98	0.704

Tl (amalg.).—(*Continued*)

x_{Tl}	x_{Tl}/x_{Hg}	$(a/x)_{Tl(576.1)}$	$(a/x)_{Hg(576.1)}$
0		1	1
0.10		1.53	0.98
0.20		1.86	0.95
0.30		2.05	0.92
0.40		2.17	0.89
0.50		2.23	0.87
0.60		2.28	0.85
0.70		2.30	0.83
0.80		2.31	0.82
(1.00)		(2.32)	(0.80)

x_{Tl}	$\bar{L}_{Tl(303.1)}$	$\bar{L}_{Hg(303.1)}$
0.0000	0	0.0
0.0250	212	− 3.1
0.0500	413	− 10.2
0.0863	671	− 28.1
0.1000	750	− 37.2
0.1070	800	− 41.8
0.1500	1 013	− 75.8
0.2000	1 195	−112
0.2500	1 324	−144
0.3000	1 415	−176
0.3500	1 478	−207
0.4000	1 520	−232
1.000 (extrapolated)	1 640	
Tl (s, satd. with Hg)	805	

x_{Tl}	$\bar{C}_{pHg(303.1)}$	$\bar{C}_{pTl(303.1)}$
0.00	6.70	10.20
0.05	6.72	9.81
0.10	6.75	9.54
0.15	6.80	9.15
0.20	6.85	8.82
0.25	6.93	8.62
0.30	6.97	8.50
0.35	7.02	8.40
0.40	7.05	8.34
1.00 (extrapolated)		8.2

$Tl(l)$ = Tl (amalg., $x = 1$)

$\Delta F^0 = -2\ 246 - 2.0T \ln T + 14.82T$; $\Delta F^0_{298.1} = -1\ 225$; $\Delta H^0_{298.1} = -1\ 650$ *from* (883, 885) *from* (623, 1218)

Tl (in 90. 5 − 96% amalg.) = Tl (in het. amalg.)

$E_{291.1} = 0.0013$ (1223); $\Delta F = -614 - 1.95T \ln T + 13.069T$; $\Delta F_{298.1} = -30$; $\Delta H_{298.1} = -33$

Tl^+; $Tl(s)$, Tl^+

$E^0_{298.1} = 0.3363$; $\Delta F^0_{298.1} = -7\ 760$ (883) *from* (470); *cf.* (9, 186, 732, 803, 1061, 1218, 1348, 1413)

$Tl^+ = Tl^{+++} + 2E^-$ (8, 9)

Grube and Hermann (520) give Pt, Tl^+, Tl^{+++}, $E^0_{291.1} = -1.211$

$TlOH(s)$; $\Delta F^0_{298.1} = -45\ 400$ (883)

$TlOH(s) = Tl^+ + OH^-$

$m_{\pm}(298.1) = 1.70$ (42); $\Delta F^0_{298.1} = 190$ (885)

$TlCl(s)$; $\Delta F^0_{298.1} = -44\ 195$

$TlCl(s) = Tl^+ + Cl^-$

$K_{298.1} = 2.78 \times 10^{-4}$; $\Delta F^0_{298.1} = 5\ 086$ (1192)

$TlCl.3NH_3(s) = TlCl(s) + 3NH_3(g)$ (108) (E)

T	P*	T	P*
194.1	0.050	223.1	0.382
213.1	0.205	$\Delta H = ca.\ 21\ 300$	

* The pressure hardly differs from that of pure NH_3.

$TlCl_3.3NH_3(s)$ = Solid solution + $xNH_3(g)$ (395) (E)

T	P	T	P
294.6	0.032	350.6	0.316
307.1	0.070	374.1	0.905
327.1	0.142	376.1	1.000 (extrap.)
	$\Delta H = 13\ 400x$		

$TlBr(s)$; $\Delta F^0_{298.1} = -39\ 770$

$TlBr(s) = Tl^+ + Br^-$; $\Delta F^0_{298.1} = 7\ 420$ (774)

$TlCl(s) + Br^- = TlBr(s) + Cl^-$ (505)

c (KCl or KBr)	$E_{298.1}$	c (KCl or KBr)	$E_{298.1}$
0.025	0.0958	0.1	0.1007
0.05	0.0991	0.2	0.1013
	$\Delta F^0_{298.1} = -2\ 340$		

$TlBr.3NH_3(s) = TlBr(s) + 3NH_3(g)$ (E)

$P_{213.1} = 0.211$; $P_{223.1} = 0.378$; $\Delta H = ca.\ 21\ 300$ (395)

$TlCl(s) + BrO_3^- = TlBrO_3(s) + Cl^-$

At 312.85°K, $K_c = 1.246$ and $\Delta F^0 = -137$ (1077)

$TlI(s)$; $\Delta F^0_{298.1} = -30\ 020$

$TlI(s) = Tl^+ + I^-$

$\Delta F^0_{298.1} = 9\ 883$ from $s_c = 0.000243$, interpolated from conductivity (774); $\Delta F^0_{298.1} = 9\ 933$ from $s_c = 0.0002352$; at 273.1°K, $s_c = 0.0000587$ (732)

$TlI.3NH_3(s) = TlI(s) + 3NH_3(g)$ (107) (E)

T	P*	T	P*
194.1	0.050	223.1	0.361
213.1	0.209	$\Delta H = ca.\ 21\ 300$	

* The pressure hardly differs from that of pure NH_3.

$TlCl(s) + CNS^- = TlCNS(s) + Cl^-$ (772)

T	$c_{(KCl+KCNS)}$	K_c
273.9	0.10	1.736
293.1	0.10	1.241
313.0	0.10	0.850

$K_{298.1} \doteq 1.13$; $\Delta F^0_{298.1} = -74$ (772); at 298.1°K, $K_c = 1.112$ and $\Delta F^0 = -63$ *from* (1075); at 312.85°K, $K_c = 0.841$ and $\Delta F^0 = 107$ *from* (1077)

$TlBrO_3(s) + CNS^- = TlCNS(s) + BrO_3^-$

At 312.85°K, $K_c = 0.677$ and $\Delta F^0 = 243$ *from* (1077)

$Tl_2O(s)$; $\Delta F^0_{298.1} = -32\ 410$ (885)

$2TlOH(s) = Tl_2O(s) + H_2O(g)$ (42) (E)

$\Delta F^0_{298.1} = 3\ 880$ (885)

T	P	T	P
319.4	0.017	378.5	0.214
344.6	0.030	383.7	0.279
352.2	0.055	389.6	0.367
356.3	0.070	395.3	0.479
362.6	0.096	403.1	0.670
364.9	0.109	408.8	0.886
370.4	0.145	413.1	1.013
374.7	0.178	$\Delta H = 15\ 200$	

$2TlClO_3(s) + SO_4^{--} = Tl_2SO_4(s) + 2ClO_3^-$

At 293.1°K, $K_c = 0.164$ and $\Delta F^0 = 1\ 055$ *from* (1078)

$Tl_2(SO_4)_3.10NH_3(s)$ = (?) + $xNH_3(g)$ (395) (E)

T	P	T	P
333.1	0.228	373.1	1.013
348.1	0.408	$\Delta H = 13\ 300x$	

Zn, Zinc

$Zn(g)$; $C_p = 5.0$; *see* **$Zn(s) = Zn(g)$**

$Zn(l)$; $C_p = 7.24$ (166); *see* **$Zn(s) = Zn(l)$**

$Zn(l) = Zn(g)$

$\Delta F^0 = 30\ 540 + 2.24T \ln T - 41.760T$; $\Delta F^0_{298.1} = 21\ 887$ (936) *from* (166, 365, 511, 616, 617, 1233, 1234, 1556)

$Zn(s) = Zn(g)$

$\Delta F^0 = 31\ 515 + 0.10T \ln T + 0.0015T^2 - 29.932T$; $\Delta F^0_{298.1} = 22\ 885$ (936) *from* (368)

$Zn(s)$; ΔF^0, $\Delta H^0 = 0$; $C_p = 5.10 + 0.003T$ (365)

$Zn(s) = Zn(l)$

$\Delta F^0 = 975 - 2.14T \ln T + 0.0015T^2 + 11.828T$; $\Delta F^0_{298.1} = 998$ (936) *from* (492, 511. 618, 663, 971, 1131, 1556)

Zn^{++}

$E^0_{298.1} = 0.7581$; $\Delta F^0_{298.1} = -17\ 492$ (885) *from* (648)

$ZnO(s)$

$C_p = 9.96 + 0.00298T - 0.000000387T^2$ (940) *from* (322.5)

$\Delta F^0_{298.1} = -75\ 720$; $\Delta S^0_{298.1} = -23.62$ (940); *cf.* (938)

$ZnO(s) + H_2(g) = Zn(l) + H_2O(g)$ (491)

$ZnO(s) + C = Zn(g) + CO(g)$ (137, 842)

$ZnO(s) + CO(g) = Zn(g) + CO_2(g)$

$\Delta F^0 = 47\ 290 + 4.46T \ln T - 0.00156T^2 - 0.0000002455T^3 - 60.305T$ (range 825 to 1120°K); $\Delta F^0_{298.1} = 36\ 855$ (941); *cf.* (137, 459, 842, 1097)

$Zn^{++} + H_2O(l) = H^+ + ZnOH^+$

In $ZnCl_2$ (aq) (800)

c	% Hydrolysis at 358.6°K	% Hydrolysis at 373.1°K
0.00392		0.137
.0157	0.0368	.0760
.125	.0421	.0835

In $ZnSO_4$ (aq) at 373.1°K (800)

c	% Hydrolysis
0.00392	0.110
.0157	.0416
.065	.0244

In $Zn(NO_3)_2$ (aq) (800)

c	% Hydrolysis at 358.6°K	% Hydrolysis at 373.1°K
0.00392	0.0421	0.0784
.0157		.0470
.125	.0242	.0309

$Zn(OH)_2(s) + 2OH^- = ZnO_2^{--} + 2H_2O(l)$; $K = 180$ (1551)

$Zn(OH)_2(s) + OH^- = ZnO_2H^- + H_2O(l)$

At 298.1°K (1551); *cf.* (1027)

$c_{(NaOH)}$	$c_{(Zn)}$	$c_{(NaOH)}$	$c_{(Zn)}$
0.2636	0.00311	0.5414	0.0129
.3871	.0057	.9280	.0425

$Zn(OH)_2$ (aq) = $H^+ + ZnO_2H^-$

$K = >0.5 \times 10^{-12}$ (1360); *cf.* (763, 1027)

$ZnCl_2(l) + H_2(g) = Zn(l) + 2HCl(g)$ (40)

$ZnCl_2$. lowest hydrate = $ZnCl_2(s)$ + aq (E)

$P_{298.1} = 0.00112$; $P_{323.1} = 0.00288$ (70)

$ZnCl_2.NH_3(s) = ZnCl_2(s) + NH_3(g)$ (E)

$P_{489.1} = 0.0088$ (801); $P_{703.1} = 0.132$ (extrap.); $\Delta H = 25\ 000$ (104)

$ZnCl_2.2NH_3(s) = ZnCl_2.NH_3(s) + NH_3(g)$ (104, 801) (E)

T	P	T	P
400.6	0.000061	483.9	0.039
429.1	0.00186	489.1*	0.057
457.6	0.00667	$\Delta H = 19\ 200$	

* From (801); all other values from (104).

$ZnCl_2.4NH_3(s) = ZnCl_2.2NH_3(s) + 2NH_3(g)$ (104, 388, 801) (E)

T	P*	T	P*
292.8	0.0155	351.1†	0.5291
308.0	0.0406	353.3	0.5554
327.1	0.132	365.1‡	0.961
338.2	0.2635	$\Delta H = 23\ 640$	

* Isambert (666) found pressures a little higher.
† From (801).
‡ From (388); all other values from (104).

$ZnCl_2.6NH_3(s) = ZnCl_2.4NH_3(s) + 2NH_3(g)$ (104, 379, 801); *cf.* (390, 666) (E)

T	P	T	P
260.1	0.008	318.1	0.483
273.1	0.029	319.9*	0.5095
283.1	0.059	323.1	0.630
290.2*	0.0939	326.1	0.717
292.1	0.108	329.1	0.837
296.1*	0.132	330.6	0.897
300.1	0.172	333.1	1.009
308.0*	0.2731	334.4	1.054
312.1	0.353	351.1†	2.150

* From (104). † From (801); all other values from (379).

The values of (666) and (390) show good agreement with the above.

According to Ephraim (388), the decomposition goes first to NH_3 content of 4.4 moles ($P_{330.9} = 0.953$); between 4.4 and 4.0 moles NH_3 lies a series of solid solutions which show $P = 0.961$ for the following:

Moles NH_3	4.3	4.1	4.0
T, °K	332.1	334.6	336.6

$ZnCl_2.10NH_3(s) = ZnCl_2.6NH_3(s) + 4NH_3(g)$ (104) (E)

T	P	T	P
194.6	0.0380	213.1	0.1871
203.1	0.0816	218.1	0.2769
208.1	0.1237	223.1	0.3923
	$\Delta H = 28\ 280$		

$ZnCl_2.5CH_3NH_2(s) = (?) + xCH_3NH_2(g)$ (393) (E)

T	P	T	P
310.6	0.082	348.6	0.579
324.6	0.130	360.1	1.000 (extrap.)
338.6	0.342	$\Delta H = 12\ 790x$	

$Zn(ClO_3)_2.4NH_3(s) = ? + xNH_3(g)$ (391) (E)

T	P	T	P
387.1	0.021	450.1	0.116
413.1	0.042	489.1	1.000 (extrap.)
438.1	0.066		

$Zn(ClO_3)_2.6NH_3(s) = Zn(ClO_3)_2.4NH_3(s) + 2NH_3(g)$ (391) (E)

T	P	T	P
258.1	0.296	274.1	0.591
259.1	0.305	276.1	0.639
263.1	0.355	279.1	0.724
265.1	0.400	280.6	0.782
267.1	0.437	283.1	0.908
271.1	0.511	284.1	0.983
273.1	0.562	$\Delta H = 19\ 600$	

$Zn(ClO_4)_2.6H_2O(s) = Zn(ClO_4)_2.4H_2O(s) + 2H_2O(g)$ (1290) (E)

T	P	T	P
373.1*	0.011	503.1	0.036
391.1	0.029	523.1	0.045
398.1	0.029	533.1†	0.064
483.1	0.032		

* Transition point at 373.1°K. † Decomposition begins at 533.1°K.

$Zn(ClO_4)_2.4NH_3(s) = (?) + xNH_3(g)$ (1290) (E)

T	P	T	P
343.1	0.009	503.1	0.038
373.1	0.029	523.1	0.042
383.1	0.032	553.1	0.064
408.1	0.032	583.1	0.087
438.1	0.033	598.1	0.136
473.1	0.036		

$Zn(ClO_4)_2.6NH_3(s) = Zn(ClO_4)_2.4NH_3(s) + 2NH_3(g)$ (390) (E)

T	P	T	P
265.1	0.063	295.1	0.383
270.6	0.100	301.1	0.507
276.1	0.139	308.1	0.721
283.1	0.204	315.1	1.033
289.1	0.280	$\Delta H = 22\ 000$	

$ZnBr_2$. lowest hydrate = $ZnBr_2(s)$ + aq (70) (E)

T	P	T	P
273.1	0.00037	323.1	0.00834
298.1	0.00153		

$ZnBr_2.NH_3(s) = ZnBr_2(s) + NH_3(g)$ (E)

$P_{678.1} = 0.132$ (104, 666); $\Delta H = 24\ 000$ (104)

$ZnBr_2.2NH_3(s) = ZnBr_2.NH_3(s) + NH_3(g)$ (104) (E)

T	P	T	P
403.1	0.000021	457.6	0.00305
429.1	0.00083	$\Delta H = 19\ 900$	

$ZnBr_2.4NH_3(s) = ZnBr_2.2NH_3(s) + 2NH_3(g)$ (104); *cf.* (388) (E)

T	P	T	P
328.8	0.0095	384.1	0.257
352.7	0.0439	$\Delta H = 27\ 100$	

$ZnBr_2.6NH_3(s) = ZnBr_2.4NH_3(s) + 2NH_3(g)$ (388) (E)

The decomposition exhibits a continuous series of solid solutions, whose dissociation points lie very near one another. The following results are for $P = 0.953$ atm.:

Moles NH_3	T	Moles NH_3	T
6.00	333.6	4.5	341.1
5.60	339.1	4.05	341.6
5.1	340.1	$\Delta H = 22\ 040$	

But the pressure is dependent upon the previous history. Fresh $ZnBr_2.6NH_3$ dissociates at 335.1°K; a day old at 333.6°K (388). Of the three vapor pressure curves of (104, 379, 388), the first two only agree fully and show $P = 1.00$ at 341.6, and $P = 0.132$ at 304.6

T (388)	P	T (388)	P
285.1	0.039	323.1	0.482
295.1	0.095	326.1	0.568
300.1	0.129	331.1	0.739
307.1	0.196	333.1	0.829
314.1	0.292	336.1	0.957
318.1	0.364	337.1	1.000

$ZnBr_2.5CH_3NH_2(s) = (?) + xCH_3NH_2(g)$ (395) (E)

T	P	T	P
318.1	0.124	338.1	0.505
330.1	0.318	352.1	1.000 (extrap.)
	$\Delta H = 12\ 480x$ (393)		

$ZnI_2.NH_3(s) = ZnI_2(s) + NH_3(g)$ (E)

$P_{613.1} = 0.132$; $\Delta H = 22\ 000$ (104)

$ZnI_2.2NH_3(s) = ZnI_2.NH_3(s) + NH_3(g)$ (E)

$P_{429.1} = 0.00139$; $P_{457.5} = 0.0056$; $\Delta H = 19\ 420$ (104)

$ZnI_2.4NH_3(s) = ZnI_2.2NH_3(s) + 2NH_3(g)$ (104) (E)

T	P	T	P
329.1	0.00082	429.5	0.1648
353.1	0.00372	457.7	0.5070
383.8	0.018	484.1*	1.000

$\Delta H = 30\ 760$

* Ephraim (388) finds $P = 1.00$ at $T = 472.1°K$.

$ZnI_2.6NH_3(s) = ZnI_2.4NH_3(s) + 2NH_3(g)$ (104, 388) (E)

T	P	T	P
273.1*	0.0201	311.1	0.255
284.1	0.049	311.6	0.258
287.1	0.059	317.1	0.362
288.2*	0.054	319.4*	0.3401
290.1	0.071	321.1	0.450
294.1	0.087	322.1	0.468
301.6	0.139	327.3	0.616
302.1*	0.132	331.1	0.741
307.1	0.195	336.1	0.987
307.4*	0.191		

$\Delta H^* = 21\ 860$

* From (104); all other values from (388).

There possibly exist between $ZnI_2.6NH_3$ and $ZnI_2.5.7NH_3$ solid solutions, for which Ephraim (388) found $P = 0.961$ as follows:

Moles NH_3	T	Moles NH_3	T
5.92	332.1	5.03	338.1
5.79	336.1	4.08	338.6

$ZnI_2.5CH_3NH_2(s) = (?) + xCH_3NH_2(g)$ (393) (E)

T	P	T	P
314.1	0.258	330.1	0.513
323.1	0.393	344.1	1.000 (extrap.)

$\Delta H = 12\ 170x$

$Zn(IO_3)_2.4NH_3(s) = (?) + xNH_3(g)$ (391) (E)

T	P	T	P
350.1	0.058	392.1	0.318
364.6	0.107	403.1	0.468
379.6	0.186	417.1	1.000 (extrap.)

$ZnSO_3.3NH_3(s) = (?) + xNH_3(g)$ (390) (E)

T	P	T	P
325.1	0.078	369.1	0.329
334.1	0.101	379.1	0.658
347.1	0.134	387.1	1.039
360.1	0.204		

$\Delta H = 13\ 800x$

$ZnSO_4.H_2O(s) = ZnSO_4(s) + H_2O(g)$ (E)

$P_{298.1} = 0.0013$ (430); *cf.* (1030, 1325)

$ZnSO_4.6H_2O(s) = ZnSO_4.H_2O(s) + 5H_2O(g)$ (430, 458, 1090); *cf.* (1030, 1325) (E)

$\Delta H = 11\ 400$, calculated from pressures

T	P	T	P
290.95	0.0104	298.25	0.01749
293.55	0.01247	302.00	0.02295
298.1*	0.0168	303.05	0.02447
298.1†	0.0171	304.80	0.02773

* From (430). † From (1090); all other values from (458).

$ZnSO_4.7H_2O(s) = ZnSO_4.6H_2O(s) + H_2O(g)$ (430, 458, 641, 843, 844, 895, 1335, 1524); *cf.* (1030, 1033, 1325) (E)

$\Delta H = 3\ 440$ (458)

T	P	T	P
283.1*	0.0064	293.1§	0.0138
289.6	0.0096	293.55‡	0.01326
291.10†	0.01106	295.1	0.0166
293.1*	0.0120	298.1‖	0.0179
298.1¶	0.02018	323.1	0.0962
298.25‡	0.01934	328.1	0.1192
301.45‡	0.02518	333.1	0.1499
303.05‡	0.02814	339.1	0.1914
303.1*	0.0249	343.1	0.2248
307.3†	0.0393	348.1	0.2911
307.6	0.0375	351.9	0.3401
313.1	0.0582	358.6	0.4953
318.1	0.0757	361.1	0.562

* From (843, 844). † From (895); all other values from (1524). ‡From (458). § ± 0.2° from (641). ‖ From (430). ¶ From (1335).

$ZnSO_4.3NH_3(s) = ZnSO_4.2NH_3(s) + NH_3(g)$ (E)

$P_{458.1} = 0.953$ (388)

$ZnSO_4.4NH_4(s) = ZnSO_4.3NH_3(s) + NH_3(g)$ (E)

$P_{371.6} = 0.953$ (388)

$ZnSO_4.5NH_3(s) = ZnSO_4.4NH_3(s) + NH_3(g)$ (regular series of solid solutions (388) (E)

The following results are for $P = 0.953$:

Moles NH_3	T	Moles NH_3	T
5.0	292.1	4.3	314.1
4.5	305.1	4.01	321.1

$ZnSO_4.6NH_3(s) = (?) + xNH_3(g)$ (regular series of solid solutions) (388) (E)

The following results are for $P = 0.953$:

Moles NH_3	T	Moles NH_3	T
6 *ca.*	238.1	5.3	267.1
5.6	254.1	5.2	274.1

$2ZnSO_4(s) + 2HCl(g) = ZnSO_4.H_2SO_4(s) + ZnCl_2(s)$

$P_{273.1} = 0.510$; $P_{285.4} = 1$ (extrap.) (959)

$ZnS_2O_3.3NH_3(s) = (?) + xNH_3(g)$ (E)

$P_{423.1} = 0.25$ (390)

$ZnS_2O_3.5NH_3(s) = ZnS_2O_3.3NH_3(s) + 2NH_3(g)$ (390) (E)

T	P	T	P
288.1	0.037	317.1	0.424
297.1	0.097	327.1	0.834
310.1	0.275	332.1	1.039

$\Delta H = 23\ 400$

$ZnS_2O_6.5NH_3(s) = (?) + xNH_3(g)$ (390) (E)

T	P	T	P
First form			
297.1	0.036	333.1	0.507
313.1	0.101	340.1	0.829
327.1	0.322		
Second form			
320.1	0.246	342.1	0.941
333.1	0.550	343.1	1.000 (extrap.)

$\Delta H = 12\ 100x$

$ZnS_4O_6.3NH_3(s) = (?) + xNH_3(g)$ (390) (E)

Vapor pressure curve uncertain

$ZnS_4O_6.5NH_3(s) = ZnS_4O_6.3NH_3(s) + 2NH_3(g)$ (390) (E)

T	P	T	P
275.1	0.028	310.1	0.259
284.1	0.047	315.1	0.424
293.1	0.072	318.1	0.458
298.1	0.117	323.1	0.708
301.1	0.142	332.1	1.049
306.1	0.195		

$\Delta H = 23\ 400$

$Zn(NO_2)_2.NH_3(s) = (?) + xNH_3(g)$ (390) (E)

T	P	T	P
298.1	0.033	346.1	0.176
318.1	0.072	353.1	0.208
328.1	0.104	359.1	0.238
337.1	0.136	$\Delta H = 14\ 600x$	

$Zn(NO_3)_2.4NH_3(s) = Zn(NO_3)_2.3NH_3(s) + NH_3(g)$ (388, 390) (E)

T	P	T	P
380.1	0.024	446.1	0.234
393.1	0.037	456.1	0.358
407.1	0.051	463.1	0.479
418.1	0.074	474.1	0.747
427.1	0.105	479.1*	0.953
434.1	0.142	481.1	1.000
440.1	0.182	$\Delta H = 17\ 600$	

* Value from (388), particularly reliable; all other values from (390).

$Zn(NO_3)_2.6NH_3(s) = Zn(NO_3)_2.4NH_3(s) + 2NH_3(g)$ (388, 390) (E)

T	P	T	P
273.1	0.209	298.1	0.699
279.1	0.284	303.1	0.876
283.1	0.349	303.6*	0.953
288.1	0.442	306.1	0.995
293.1	0.557	$\Delta H = 21\ 400$	

* Value from (388), particularly reliable; all other values from (390).

$(NH_4)_2Zn(SO_4)_2.6H_2O(s) = (NH_4)_2Zn(SO_4)_2.2H_2O(s) + 4H_2O(g)$ (264) (E)

$\log P = 2.755 + 471.5/T - 622\ 000/T^2$

T	P	T	P
303.8	0.0037*	332.8	0.0361
315.6	0.0097	337.8	0.0497*
318.1	0.0122*	341.1	0.0616*
320.7	0.0143	343.3	0.0708
328.7	0.0270	352.5	0.1219
329.6	0.0287*	$\Delta H = 61\ 600$	

* Measured on cooling.

$Zn(OH)_2(s) + 4NH_3C_2H_5OH(aq) = Zn(NH_2C_2H_5)_4^{++} + 2OH^- + 4H_2O(l)$ (607)

$c_{(NH_3C_2H_5OH)}$ total	$c_{(Zn)}$	$c_{(NH_3C_2H_5OH)}$ total	$c_{(Zn)}$
0.068	0.00015	0.68	0.0049
.51	.00225		

$Zn[I(As_2O_3)_2]_2.4NH_3(s) = Zn[I(As_2O_3)_2]_2.2NH_3(s) + 2NH_3(g)$ (E)

$P_{473.1} = 1.00$ (396)

$Zn[I(As_2O_3)_2]_2.6NH_3(s) = Zn[I(AsO_3)_2]_2.4NH_3(s) + 2NH_3(g)$ (396) (E)

Decomposition between 343.1 and 360.1°K gives a series of solid solutions

$Zn[I(As_2O_3)_2]_2.7NH_3(s) = Zn[I(As_2O_3)_2]_2.6NH_3(s) + NH_3(g)$ (396) (E)

Decomposition begins at 253.1°K, and leads through a series of solid solutions, to the hexammine at 343.1°K

$ZnCO_3(s) = ZnO(s) + CO_2(g)$

For Smithsonite, at *ca.* 668.1°K, $P = 1$ (453)

$ZnCO_3(s) + H_2CO_3(aq) = Zn^{++} + 2HCO_3^-$ (1191) *from* (1370); *cf.* (564)

$\log p.f._{298.1} = 2.292$; $\Delta H = -7\ 150$; $\Delta F^0_{298.1} = 9\ 385$

$c_{(H_2CO_3)}$	$c_{(Zn^{++})}$	$c_{(HCO_3^-)}$	$\mu_c^{1/2}$	$\log (1/K^{1/3})$
$T = 298.1°K$				
0.1390	0.00194	0.00388	0.076	2.2258
.1797	.00211	.00422	.080	2.2263
.2579	.00242	.00484	.085	2.2194
0.3580	0.00270	0.00540	0.090	2.2192
.4103	.00278	.00556	.091	2.2263
.4480	.00291	.00582	.093	2.2192
.6657	.00317	.00634	.098	2.2395
.6969	.00319	.00638	.098	2.2432
.7610	.00343	.00686	.101	2.2245
1.3701	.00445	.00890	.115	2.1965
$T = 303.1°K$				
0.1838	0.00215	0.00430	0.080	2.2216
.3838	.00277	.00554	.091	2.2181
.4038	.00286	.00572	.093	2.2117
.4601	.00308	.00616	.096	2.1981
.6064	.00324	.00648	.099	2.2163
.6257	.00337	.00674	.100	2.2037
.7470	.00352	.00704	.102	2.2105
.8351	.00376	.00752	.106	2.1979
1.0840	.00339	.00678	.101	2.2809
1.1275	.00429	.00858	.114	2.1840

$ZnC_2O_4.5NH_3(s) = ZnC_2O_4.2NH_3(s) + 3NH_3(g)$ (390) (E)

T	P	T	P
256.1	0.053	280.1	0.441
260.1	0.083	283.1	0.524
265.1	0.139	288.1	0.705
267.1	0.171	291.1*	0.841*
270.1	0.229	294.1	0.978
275.1	0.326	295.1	1.026
	$\Delta H = 30\ 600$		

* Ephraim (388) finds $P_{291.1} = 0.953$.

$Zn(HCO_2)_2.2\frac{1}{2}NH_3(s) = Zn(HCO_2)_2.2NH_3(s) + \frac{1}{2}NH_3(g)$ (E)

$P = 0.953$ from 335 to 337°K (388)

$Zn(HCO_2)_2.4NH_3(s) = Zn(HCO_2)_2.2\frac{1}{2}NH_3(s) + 1\frac{1}{2}NH_3(g)$ (388, 390) (E)

T	P	T	P
281.1	0.078	309.1	0.451
287.1	0.118	315.1	0.625
292.1	0.164	319.1	0.766
296.1	0.211	324.1	0.980
301.1	0.283	$\Delta H = 17\ 100$	

$Zn(HCO_2)_2.6NH_3(s) = Zn(HCO_2)_2.4NH_3(s) + 2NH_3(g)$ (E)

$P_{269.1} = 0.953$; decomposition to the tetrammine at 276.1°K (390)

$Zn(CNS)_2.4NH_3(s) =$ Solid solutions $+ xNH_3(g)$ (390) (E)

T	P	T	P
304.1	0.026	350.1	0.397
318.1	0.058	353.1	0.511
330.1	0.111	358.1	0.776
337.1	0.166	361.1	1.013
345.1	0.266	$\Delta H = 12\ 800x$	

$Zn(CNS)_2.6NH_3(s) = Zn(CNS)_2.4NH_3(s) + 2NH_3(g)$ (390) (E)

T	P	T	P
252.1	0.329	273.1	0.945
258.1	0.441	274.1	1.000 (extrap.)
	$\Delta H = 19\ 000$		

$Zn(CH_3CO_2)_2.2NH_3(s) = (?) + xNH_3(g)$ (390) (E)

T	P	T	P
377.1	0.043	395.1	0.129
387.1	0.075	403.1	0.236
391.1	0.097	411.1	0.451

$Zn(CH_3CO_2)_2.2NH_3(s)$.—(*Continued*)

T	P	T	P
409.1	0.368	420.1	0.930
418.1	0.783	421.1	1.037
	$\Delta H = 15\ 200$x		

$Zn(OH)_2(s) + 4NH_4OH(aq) = Zn(NH_3)_4^{++} + 2OH^- + 4H_2O(l)$ (155, 607); *cf.* (1400)

$c_{(NH_4OH)}$ total	$c_{(Zn)}$	$c_{(NH_4OH)}$ total	$c_{(Zn)}$
0.0942*	0.00055	1.215	0.0332
.236*	.0055	1.928	.0623
.321	.00417	2.570	.0862
.643	.01038	3.213	.1249
.707*	.0295		

* From (607); all other values from (155).

$Zn(OH)_2(s) + 4NH_3CH_3OH(aq) = Zn(NH_2CH_3)_4^{++} + 2OH^- + 4H_2O(l)$ (607)

$c_{(NH_3CH_3OH)}$ total	$c_{(Zn)}$	$c_{(NH_3CH_3OH)}$ total	$c_{(Zn)}$
0.0944	0.00025	0.944	0.015
.472	.00405		

$Zn(C_6H_5CO_2)_2.2NH_3(s) = (?) + xNH_3(g)$ (1457) (E)

T	P	T	P
408.1	0.141	455.1	0.704
426.1	0.218	461.1	0.939
442.1	0.388	463.1	1.000

$Zn(C_6H_5CO_2)_2.3NH_3(s) = Zn(C_6H_5CO_2)_2.2NH_3(s) + NH_3(g)$ (1457); *cf.* (388*) (E)

T	P	T	P
299.1	0.121	323.1	0.632
308.1	0.230	328.1	0.875
318.1	0.454	330.1	1.000

* According to Ephraim (388), $P = 0.953$ at T between 329.1 and 338.6°K, depending upon previous history of sample.

$Zn(C_6H_5CO_2)_2.5NH_3(s) = Zn(C_6H_5CO_2)_2.3NH_3(s) + 2NH_3(g)$ (1457); *cf.* (388) (E)

T	P	T	P
278.1	0.461	288.1	0.724
283.1	0.533	291.1	0.980
285.6	0.605	294.1	0.953

$Zn(C_6H_5CO_2)_2.8NH_3(s) = Zn(C_6H_5CO_2)_2.5NH_3(s) + 3NH_3(g)$ (1457); *cf.* (388, 390) (E)

T	P	T	P
254.1	0.346	266.1	0.770
258.1	0.408	270.6	1.000
260.1	0.528	271.1	1.058
263.1	0.632	$\Delta H = 27\ 900$	

$Zn(C_6H_5SO_3)_2.5NH_3(s) = Zn(C_6H_5SO_3)_2.4NH_3(s) + NH_3(g)$ (E)
$P = 1.00$ between 261.1°K and room temperature (1457)

Zn 2-naphtholsulfonate.$8NH_3(s)$ = **Zn 2-naphtholsulfonate.**$4NH_3(s) + 4NH_3(g)$ (1457) (E)

T	P	T	P
254.1	0.272	269.1	0.592
258.1	0.336	273.1	0.842
265.6	0.474	274.6	1.000

Zn *o*-naphthoylbenzoate with $8NH_3 = (?) + xNH_3(g)$ (1457) (E)

T	P	T	P
255.1	0.368	265.1	0.789
259.1	0.513	267.1	1.000
260.6	0.566		

$2ZnSO_4.ZnO(s) = 3ZnO(s) + 2SO_2(g) + O_2(g)$
$P_{1208.1} = 1.00$ (455)

$ZnSO_4(s) = 2ZnSO_4.ZnO(s) + SO_2(g) + \frac{1}{2}O_2(g)$
$P_{1113.1} = 1.00$ (455); *cf.* (636, 835)

Cd, Cadmium

$Cd(g)$; $C_p = 5.0$; *see* $Cd(s) = Cd(g)$

$Cd(l)$; $C_p = 7.50$ (166); *see* $Cd(s) = Cd(l)$

$Cd(l) = Cd(g)$
$\Delta F^0 = 26\ 645 + 2.50T \ln T - 43.068T$; $\Delta F^0_{298.1} = 18\ 053$ (936) *from* (166, 427, 616, 617)

$Cd(s)$
$\Delta F^0, \Delta H^0 = 0$; $C_p = 5.46 + 0.0026T$ (936) *from* (515, 1043)

$Cd(s) = Cd(g)$
$\Delta F^0 = 27\ 050 + 0.46T \ln T + 0.0013T^2 - 31.301T$; $\Delta F^0_{298.1} = 18\ 616$ (936) *from* (368)

$Cd(s) = Cd(l)$
$\Delta F^0 = 405 - 2.04T \ln T + 0.0013T^3 + 11.767$; $\Delta F^0_{298.1} = 563$ (936); *cf.* (1131, 1232, 1242)

Cd^{++}
$E^0_{298.1} = 0.3976$; $\Delta F^0_{298.1} = -18\ 348$ (885) *from* (648)

$Cd(s) = Cd$ (in het. amalg.)
$E = A - Bt$

10^4A	10^4B	$E_{298.1}$	% Amalg.	Range, °C	Lit.
566.3	2.44	0.05053	12.5	12.1–60	(661)
565.6	2.437	0.05047	10	0–51	(662)
563.9	2.42	0.05034	10	$CdSO_4(aq)$	(1093)
563.7	2.48	0.05021	10	$CdCl_2(aq)$	(1093)
562.7	2.48	0.05008	10	$CdBr_2(aq)$	(1093)
565.8	2.48	0.05040	10	$CdI_2(aq)$	(1093)

$Cd(s) = Cd$ (amalg., $x_2 = 0.0792$); $E_{298.1} = 0.0534$ (648)

Cd (satd. with Pb, Hg) $= Cd$ (in het. amalg.)
$E = 0.00113 + 0.000025\,(t - 25) + 0.0000002\,(t - 25)^2$; $E_{273.1} = 0.000630$; $E_{298.1} = 0.00113$ (1480)

$CdO(s) + H_2(g) = Cd(l) + H_2O(g)$ (491)

$Cd^{++} + H_2O(l) = H^+ + Cd(OH)^+$ (800)

$c_{(CdCl_2)}$	% hydrolysis, 373.1°K
0.0156	0.0072
0.0625	0.0045

$Cd(l) + PbCl_2(l) = CdCl_2(l) + Pb(l)$ (910, 913)

$Cd(l) + 2TlCl(l) = 2Tl(l) + CdCl_2(l)$ (910)

$CdCl_2(s)$
$\Delta F^0_{298.1} = -82\ 260$; $E^0_{568.1} = 1.54$; $\Delta F^0_{568.1} = -72\ 320$ (885) *from* (1509)

$CdCl_2.H_2O(s) = CdCl_2(s) + H_2O(l)$; $\Delta F^0_{298.1} = 1\ 320$ (885)

$CdCl_2.2\frac{1}{2}H_2O(s)$
$E^0_{298.1} = 1.8236$; $\Delta F^0_{298.1} = -84\ 156 \pm 150$ (1189) *from* (648, 901, 1093, 1099, 1429, 1482)

H_2O (in satd. $CdCl_2.2\frac{1}{2}H_2O$) $= H_2O(l)$
$\Delta F^0_{298.1} = 220$ (885) *from* (847, 1419, 1420)

$CdCl_2.2\frac{1}{2}H_2O(s) = CdCl_2.H_2O(s) + \frac{3}{2}H_2O(l)$
$\Delta F^0_{307.2} = 360$; $\Delta F^0_{298.1} = 430$ (885)

Cd (in het. amalg.) $+ PbCl_2(s) + 2\frac{1}{2}H_2O$ (in satd. $CdCl_2.2\frac{1}{2}H_2O$) $= Pb$ (amalg., $x_2 = 0.00697$) $+ CdCl_2.2\frac{1}{2}H_2O(s)$
$E_{273.1} = 0.1484$; $E_{298.1} = 0.1484$ (1429)

Cd (in het. amalg.) + $PbCl_2$(s) + 2½ H_2O (in satd. $CdCl_2.2\frac{1}{2}$ H_2O) = Pb (in het. amalg.) + $CdCl_2.2\frac{1}{2}$ H_2O(s)

$E = 0.14178 - 0.000200(t - 20) - 0.000002(t - 20)^2$; $E_{298.1} = 0.14073$; $E_{273.1} = 0.1450$ (1093); $E = 0.13759 - 0.000193(t - 25) - 0.0000012(t - 25)^2$; $E_{298.1} = 0.13759$; $E_{273.1} = 0.14157$ (1482)

Cd (satd. with Pb, Hg) + $PbCl_2$(s) + 2½H_2O (in satd. $CdCl_2.2\frac{1}{2}H_2O$) = Pb (in het. amalg.) + $CdCl_2.2\frac{1}{2}$ H_2O(s)

$E^0 = 0.13872 - 0.000168(t - 25) - 0.0000010(t - 25)^2$; $E^0_{298.1} = 0.13872$; $E^0_{273.1} = 0.14286$ (1482)

$CdCl_2$ (1, 2, and $4NH_3$)(801) (E)

$CdCl_2.6NH_3$(s) = (?) + xNH_3(g) (379); *cf.* (801, 819) (E)

T	*P*	*T*	*P*
286.6	0.068	321.6	0.596
298.1	0.142	325.1	0.697
304.1	0.224	326.6	0.758
310.6	0.326	329.1	0.836
315.1	0.432	331.1	0.934
318.1	0.500	332.6	1.007

$\Delta H = 11\ 400x$

$Cd(ClO_3)_2.4NH_3$(s) = (?) + xNH_3(g) (391) (E)

T	*P*	*T*	*P*
389.6	0.154	409.1	0.441
398.6	0.229	426.1	1.00 (interp.)

$\Delta H = 15\ 400x$

$Cd(ClO_3)_2.6NH_3$(s) = $Cd(ClO_3)_2.4NH_3$(s) + $2NH_3$(g) (391) (E)

T	*P*	*T*	*P*
342.1	0.117	376.6	0.434
355.1	0.205	389.6	0.697
367.1	0.317	395.1	1.015

$\Delta H = 28\ 200$

$Cd(ClO_4)_2.6H_2O$(s) = $Cd(ClO_4)_2.4H_2O$(s) + $2H_2O$(g) (1290) (E)

T	*P*	*T*	*P*
368.1	0.013	563.1	0.172
383.1	0.039	598.1	0.233

$Cd(ClO_4)_2.6NH_3$(s) = (?) + xNH_3(g) (1290) (E)

T	*P*	*T*	*P*
343.1	0.033	503.1	0.083
393.1	0.043	523.1	0.097
423.1	0.045	543.1	0.170
453.1	0.068	563.1	0.242
473.1	0.080		

$CdBr_2.4H_2O$(s)

$E^0_{298.1} = 1.5617$; $\Delta F^0_{298.1} = -72\ 070$ (1189) *from* (1093, 1099)

H_2O (in satd. $CdBr_2.4H_2O$) = H_2O(l)

$\Delta F^0_{298.1} = 337$ (1189) *from* (847)

Cd (in het. amalg.) + $PbBr_2$(s) + $4H_2O$ (in satd. $CdBr_2.4H_2O$) = Pb (in het. amalg.) + $CdBr_2.4H_2O$(s)

$E = 0.14505 - 0.00037(t - 20) - 0.00005(t - 20)^2$; $E_{298.1} = 0.14330$; $E_{273.1} = 0.15045$ (1093)

$CdBr_2.4H_2O$(s) = $CdBr_2$(s) + $4H_2O$(g) (847) (E)

T	*P*	*T*	*P*
293.1	0.0118	333.1	0.163

The vapor pressure is not distinguishable from that of the saturated solution.

$CdBr_2.6NH_3$(s) = (?) + xNH_3(g) (379) (E)

T	*P*	*T*	*P*
304.1	0.051	340.1	0.453
318.1	0.136	344.1	0.559
323.1	0.182	349.1	0.704
329.1	0.253	355.4	0.921
333.6	0.324	357.4	1.026

$\Delta H = 12\ 700x$

$CdBr_2.3NH_2CH_3$(s) = (?) + xNH_2CH_3(g) (393) (E)

T	*P*	*T*	*P*
316.1	0.179	349.1	1.000 (interp.)
328.1	0.353	350.6	1.072
342.6	0.743	356.1	1.283

$\Delta H = 13\ 610x$

CdI_2(s)

$E^0_{298.1} = 1.0438$; $\Delta F^0_{298.1} = -48\ 169 \pm 10$ (?) (1189) *from* (1093, 1099, 1429, 1482, 1559)

Cd (in het. amalg.) + PbI_2(s) = Pb (amalg., $x_2 = 0.000697$) + CdI_2(s)

$E_{273.1} = 0.09655$; $E_{298.1} = 0.10725$; $E_{313.1} = 0.1350$ (1429)

Cd (in het. amalg.) + PbI_2(s) = Pb (in het. amalg.) + CdI_2(s)

$E = 0.09839 + 0.000245(t - 20) - 0.000001(t - 20)^2$; $E_{298.1} = 0.09958$; $E_{273.1} = 0.09309$ (1093); $E = 0.0997 + 0.000235(t - 25) - 0.0000002(t - 25)^2$; $E_{298.1} = 0.0997$ (1482)

Cd (amalg. satd. Pb, Hg) + PbI_2(s) = Pb (in het. amalg.) + CdI_2(s)

$E = 0.1007 + 0.000026(t - 25)$; $E_{298.1} = 0.1007$; $E_{273.1} = 0.0942$ (1482)

$CdI_2.6NH_3$(s) = (?) + xNH_3(g) (379) (E)

T	*P*	*T*	*P*
291.1	0.004	364.1	0.487
297.1	0.011	367.6	0.572
317.1	0.039	372.1	0.691
332.1	0.078	372.6	0.713
337.6	0.126	376.6	0.833
342.6	0.166	377.6	0.876
351.6	0.268	380.6	0.964
358.1	0.357		

$\Delta H = 13\ 600x$

$CdI_2.3NH_2CH_3$(s) = (?) + xNH_2CH_3(g) (393) (E)

T	*P*	*T*	*P*
316.6	0.063	356.6	0.434
327.6	0.125	371.6	0.743
340.1	0.224	381.6	1.007

$\Delta H = 13\ 610x$

$Cd(IO_3)_2.4NH_3$(s) = (?) + xNH_3(g) (391) (E)

T	*P*	*T*	*P*
364.1	0.501	383.1	0.933
374.1	0.639		

Previous treatment with NH_3 in the cold:

T	*P*	*T*	*P*
296.6	0.074	327.1	0.266
304.1	0.125	338.1	0.292
314.6	0.222		

$\Delta H = 13\ 700x$

$CdSO_4$(s) = (?) + SO_2(g) + ½O_2(g) (636)

$CdSO_4.H_2O$(s) = $CdSO_4$(s) + H_2O(g) (848) (E)

T	*P*	*T*	*P*
438.1	0.072	447.6	0.213
443.1	0.151		

$CdSO_4.\frac{2}{3}H_2O(s) = CdSO_4.H_2O(s) + \frac{2}{3}H_2O(g)$ (257); *cf.* (848) (E)

T	P	T	P
298.1	0.0234	308.28	0.0461
303.28	0.0336	313.35	0.0641

$CdSO_4.4NH_3(s) = (?) + xNH_3(g)$ (380) (E)

T	P	T	P
325.6	0.151	352.1	0.691
334.1	0.263	355.6	0.796
338.1	0.322	356.1	0.836
344.6	0.447	359.6	0.974
346.1	0.507	ΔH = 12 830x	

$CdSO_4.6NH_3(s) = CdSO_4.4NH_3(s) + 2NH_3(g)$ (380) (E)

T	P	T	P
291.1	0.074	325.1	0.720
306.1	0.205	331.6	0.980
315.1	0.391	ΔH = 23 660	

$(n + 1)CdSO_4(s) + 2HCl(g) = nCdSO_4.H_2SO_4(s) + CdCl_2(s)$ (958)

T	P	T	P
338.7	0.0863	380.8	0.735
353.3	.208	390.1	.917
373.1	.509	394.1	1.000

$Cd(OH)_2(s) + 4NH_4OH(aq) = Cd(NH_3)_4^{++} + 2OH^- + 4H_2O(l)$
T = 298.1°K (155, 156)

$c_{(NH_4OH)}$ total	$c_{(Cd)}$	$c_{(NH_4OH)}$ total	$c_{(Cd)}$
0.5	0.00187	1.8	0.01037
1.0	0.00483	4.6	0.03735

$CdCO_3(s) = CdO(s) + CO_2(g)$ (269) (E)

$\log P = -43\ 630/4.6T + 15.113$ (269); $\log P = -4\ 703.1/T + 1.75 \log T - 0.0007514T + 3.2$ (20); *cf.* (272, 273, 970)

T	P	T	P
523.1	0.00066	613.1	0.434*
535.1	0.0033	615.1	0.403
553.1	0.0053	620.1	0.536
573.1	0.0079	623.1	0.750*
581.1	0.030	626.1	0.691
588.1	0.072	632.1	1.042
593.1	0.132*	633.1	1.349*
595.1	0.1324	636.1	1.574
603.1	0.250	641.1	2.062
	ΔH = 21 860		

* Interpolated according to equation: $\log P = -15.32 + 0.02439\ T$.

$Cd(C_6H_5CO_2)_2.2NH_3(s) = (?) + xNH_3(g)$ (383) (E)

T	P	T	P
431.1	0.336	453.1	0.921
441.1	0.572	455.1	0.993
447.1	0.724		

$Cd(C_6H_5CO_2)_2.4NH_3(s) = Cd(C_6H_5CO_2)_2.2NH_3(s) + 2NH_3(g)$ (383) (E)

In the decomposition, solid solution results

T	P	T	P
296.1	0.317	313.1	0.875
301.1	0.439	315.1	1.000
306.1	0.579		

$Cd(C_6H_5CO_2)_2.6NH_3(s) = Cd(C_6H_5CO_2)_2.4NH_3(s) + 2NH_3(g)$ (383) (E)

T	P	T	P
273.1	0.316	287.1	0.789
278.1	0.447	290.1	0.953
280.1	0.511	290.6	1.000
283.1	0.618		

$Cd(C_6H_5CO_2)_2.8NH_3(s) = Cd(C_6H_5CO_2)_2.6NH_3(s) + 2NH_3(g)$ (383) (E)

T	P	T	P
Fresh substance			
258.1	0.468	278.1	0.941
263.1	0.511	279.1	1.000
273.1	0.730		
Old substance			
254.1	0.330	267.1	0.632
263.1	0.483	273.1	0.901
265.1	0.559	274.6	1.000

$Cd(C_{10}H_7SO_3)_2.6NH_3(s) = (?) + xNH_3(g)$ (383) (E)

T	P	T	P
325.1	0.224	359.1	0.822
334.1	0.329	362.1	0.925
346.1	0.528	363.6	1.000
351.1	0.651		

Hg, Mercury

Hg(g)

$C_p = 5.0$; $\Delta H^0_{298.1} = 14\ 690$; $\Delta F^0_{298.1} = 7\ 632$; $\Delta S^0_{298.1} = 23.679$; $\Delta F^0 = 15\ 391 + 3.42T \ln T - 0.0049T^2 + 0.0000022T^3 - 14.252T$ (valid below 140°C) (1183)

Hg(l)

ΔH^0, $\Delta F^0 = 0$; C_p (−40 to +140°C) $= 8.42 - 0.0098T + 0.0000132T^2$; $S^0_{298.1} = 17.831$ (1183)

Hg(l′), hypothetical liquid mercury

$C_p = 6.73 - 0.001T + 0.00000156T^2$ (1183)

Hg(l) = Hg(l′) (1183)

T,°K	C_p, Hg(l)	C_p, Hg(l′)	ΔC_p	ΔS	ΔH	$T\Delta S$	ΔF
233.1	6.965	6.582	−0.383	0.06633	18.223	15.46	2.76
253.1	6.797	6.577	−0.220	.04161	12.443	10.53	1.91
273.1	6.730	6.573	−0.157	.02728	8.673	7.45	1.22
293.1	6.684	6.571	−0.113	.01769	5.973	5.18	0.79
298.1	6.676	6.570	−0.106	.01583	5.425	4.72	.71
313.1	6.650	6.570	−0.080	.01127	4.03	3.53	.50
333.1	6.626	6.570	−0.056	.00705	2.67	2.35	.32
353.1	6.610	6.572	−0.038	.00432	1.73	1.53	.20
373.1	6.599	6.574	−0.025	.00256	1.10	0.96	.14
393.1	6.593	6.578	−0.015	.00152	0.70	.60	.10
413.1	6.592	6.583	−0.009	.00093	.46	.38	.08
433.1	6.595	6.590	−0.005	.00063	.32	.27	.05
453.1	6.600	6.597	−0.003	.00045	.24	.20	.04

Hg(l′) = Hg(g)

$\Delta F^0 = 15\ 170 + 1.73T \ln T - 0.0005T^2 + 0.00000026T^3 - 35.020T$ (range 235.1 to 1708.1°K); $\Delta H^0_{298.1} = 14\ 685$; $\Delta S^0_{298.1} = 23.663$; $\Delta F^0_{298.1} = 7\ 631$ (1183) *from* (85, 234, 368, 549, 770, 771, 984, 985, 1149, 1168.5, 1234, 1378, 1379, 1380); *cf.* (427)

Hg(s)

C_p (above 100°K) $= 5.31 + 0.00614T$ (1183); *see* **Hg(l) = Hg(s)**

Hg(s) = Hg(g)

$\Delta F^0 = 15\ 595 + 0.31T \ln T - 0.00307T^2 - 29.90T$ (1183)

$Hg(l) = Hg(s)$

$\Delta F^0_{234.23} = 0$ (1183) *from* (604, 1527, 1528); $\Delta H^0_{298.1} = -551.7$ (1151); $\Delta F^0 = -204 + 3.11T \ln T - 0.00797T^2 + 0.0000022T^3 - 14.352T$; $\Delta H^0_{298.1} = -539.4$; $\Delta F^0_{298.1} = 149.3$ (1183)

Hg_2^{++}

$E^0_{298.1} = -0.7986$; $\Delta F^0_{298.1} = 36\ 854$ (885)

$Hg_2^{++} + H_2(g) = 2Hg(l) + 2H^+$ (885, 896, 1096)

$HgO(red)$

$C_p = 9.00 + 0.006T$ (885); $\Delta H = -21\ 500$ (1468) $= -21\ 700$ (190, 191); $\Delta H^0_{298.1} = -21\ 600$ (1183, 1185); $\Delta F^0_{298.1} = -13\ 808$ (885); $= -13\ 950$ (1183) *from* (1427); $= -14\ 063$ (1183) from third law of thermodynamics

HgO (red) $= Hg(g) + \frac{1}{2}O_2(g)$ (1183) *from* (1427); *cf.* (1123)

$\Delta F^0 = 36\ 728 + 0.75T \ln T + 0.00275T^2 - 56.000T$; $\Delta H^0_{298.1} = 36\ 290$; $\Delta F^0_{298.1} = 21\ 582$

T,°K	Total P in atm.	$-R \ln K$	I
633.1	0.1185	8.262	−56.377
643.1	.1422	7.719	−56.058
653.1	.1858	6.923	−56.016
663.1	.2370	6.195	−55.936
673.1	.3040	5.451	−55.872
683.1	.3990	4.642	−55.943
693.1	.5095	3.911	−55.935
703.1	.6550	3.159	−55.972
713.1	.8450	2.402	−56.033
723.1	1.067	1.709	−56.052
733.1	1.339	1.030	−56.074
743.1	1.679	0.3554	−56.113
753.1	2.081	.2862	−56.562

HgO (red) $+ H_2(g) = Hg(l) + H_2O(l)$ (1183)

$E^0_{298.1} = 0.9264$; $\Delta F^0_{298.1} = -42\ 752$

Hydroxide	m	$E^0_{298.1}$	Lit.
NaOH	0.672	0.9263	(190, 191)
	4.80	.9293	
	10.00	.9355	
	0.316	.92640	(279)
	.101	.92637	
	.0316	.92644	
	.0103	.92608	
	.00310	.92637	
	.00105	.92666	
KOH	.09635	.92646	(218)

Cd (in het. amalg.) $+ HgO(s) = CdO(s) + Hg(l)$

$E_{298.1} = 0.824$; $\Delta F_{298.1} = -38\ 040$ (930)

Cd (in het. amalg.) $+ HgO(s) + H_2O(l) = Hg(l) + Cd(OH)_2(s)$ (930)

In NaOH, m	$E^0_{298.1}$	$\Delta F^0_{298.1}$
1.0	0.8595	−39 667
13.0	0.85014	−39 232

HgO (red) $+ 2HF(aq) = HgF_2(aq) + H_2O(l)$ (679)

$c_{(HF)}$	$c_{(HgF_2)}$	$c_{(HF)}$	$c_{(HgF_2)}$
0.12	0.01258	1.11	0.1168
.24	.0247	2.17	.2586
.57	.0629		

$HgCl(s)$

$E^0_{298.1} = 1.0905$; $\Delta F^0_{298.1} = -25\ 163 \pm 5$ (1189) *from* (470); *cf.* (193, 1195, 1548)

$Hg(l) + \frac{1}{2}Cl_2$ (1 atm. actual) $= HgCl(s)$

$E = 1.1040 - 0.000945t$; $E_{298.1} = 1.0904$ (1189) *from* (470); $E = 1.1090 - 0.00100t$; $E_{298.1} = 1.0843$ (1189) *from* (1548)

$\frac{1}{2}H_2(g) + HgCl(s) = Hg(l) + H^+ + Cl^-$

$E^0_{298.1} = 0.2700$; $\Delta F^0_{298.1} = -6\ 230$ (885); revised value, $E^0_{298.1} = 0.2676$; $\Delta F^0_{298.1} = -6\ 175$ (1195); *cf.* (261, 372, 576, 578, 579, 864, 897, 898, 907, 909, 1172, 1443)

$\frac{1}{2}H_2(g) + NH_4OH$ $(0.05m)$ $+ HgCl(s) = Hg(l) + NH_4Cl(s) + H_2O$ (in satd. NH_4Cl)

$E_{298.1} = 0.6924$; $\Delta F_{298.1} = -15\ 980$ (193); $\Delta H = -70\ 600$; $\Delta F^0_{298.1} = -14\ 670$ (1189)

$Pb(s) + 2HgCl(s) = 2Hg(l) + PbCl_2(s)$

$E = A + Bt$

A	B	$E_{298.1}$	Lit.
0.5321	0.000147	0.5358	(470)
0.5277	0.000210	0.5329	(530)
0.5274	0.00020	0.5324	(792)

Pb (in het. amalg.) $+ 2HgCl(s) = 2Hg(l) + PbCl_2(s)$

$E = 0.5265 + 0.00013t$; $E_{298.1} = 0.5298$ (37); $E = 0.52657 + 0.000133t$; $E_{298.1} = 0.5299$ (470)

Pb (amalg., $x_2 = 0.00697$) $+ 2HgCl(s) = 2Hg(l) + PbCl_2(s)$

$E_{298.1} = 0.5224$ (1429)

Tl (in het. amalg.) $+ HgCl(s) = Hg(l) + TlCl(s)$

$E_{298.1} = 0.8225$; also Tl (in het. amalg.), TlCl(s), 0.1 KCl, *N*-electrode, $E_{298.1} = 0.7704$ (891)

Cd (in het. amalg.) $+ 2HgCl(s) + 2\frac{1}{2}H_2O$ (in satd. $CdCl_2.2\frac{1}{2}H_2O$) $= 2Hg(l) + CdCl_2.2\frac{1}{2}H_2O(s)$

$E = 0.67080 - 0.000102(t - 25) - 0.0000025(t - 25)^2$; $E_{298.1} = 0.67080$; $E_{273.1} = 0.67329$ (901); $E = 0.67179 - 0.000074(t - 18) - 0.0000015(t - 18)^2$; $E_{298.1} = 0.67118$; $E_{273.1} = 0.67254$ (1099)

$HgCl.2NH_3(s) = (?) + xNH_3(g)$ (E)

$P_{631.1} = 0.887$; $P_{640.1} = 1.202$ (666); $\Delta H = 14\ 330x$ (153)

$HgCl_2(g)$

$\Delta H^0_{298.1} = -36\ 658$; $\Delta F^0_{298.1} = -34\ 569$ (1183)

$2HgCl(s) = HgCl_2(g) + Hg(g)$

$\Delta F^0 = 41\ 350 - 60.271T$ (range 363 to 676°K); $\Delta H^0_{298.1} = 41\ 350$; $\Delta F^0_{298.1} = 23\ 383$; $\Delta C_p = 0$ (1183) *from* (404, 1198, 1372, 1380, 1525)

$HgCl_2(l)$

$\Delta H^0_{298.1} = -51\ 938$; $\Delta F^0_{298.1} = -41\ 932$ (1183)

$HgCl_2(l) = HgCl_2(g)$

$\Delta F^0 = 15\ 280 - 26.557T$ (range 551 to 575°K); $\Delta F^0_{298.1} = 7\ 363$ (1183) *from* (713)

$HgCl_2(s)$

$\Delta H^0_{298.1} = -55\ 428$; $\Delta F^0_{298.1} = -43\ 550$ (1183)

$HgCl_2(s) = HgCl_2(g)$

$\Delta F^0 = 18\ 770 - 32.837T$ (range 363 to 548°K); $\Delta H^0_{298.1} = 18\ 770$; $\Delta F^0_{298.1} = 8\ 981$ (1183) *from* (713, 1525)

$HgCl_2(s) = HgCl_2(l)$

$\Delta F^0 = 3\ 490 - 6.280T$; $\Delta F^0_{555.7} = 0$ (1183); *cf.* (713, 733); $\Delta F^0_{548.1} = 0$ (1293); $\Delta F^0_{550.5} = 0$ (1105)

$HgCl_2(aq) + H_2O(l) = Hg(OH)^+ + H^+ + 2Cl^-$ (800)

$c_{(HgCl_2)}$	% Hydrolysis at 358.6°K	% Hydrolysis at 373.6°K
0.000977	4.87	6.91
.00392	2.31	2.99
.0157	1.06	1.35
.0625	0.451	0.60

$\mathrm{HgBr(s)}$

$E^0_{298.1} = 0.9253$; $\Delta F^0_{298.1} = -21\ 351 \pm 10$ (1189) *from* (472, 1183)

$\tfrac{1}{2}\mathrm{H_2(g) + HgBr(s) = Hg(l) + H^+ + Br^-}$

$E_{298.1}$ ($m = 0.10015$) $= 0.2685$ (472); $E^0_{298.1} = -0.1397$; $\Delta F^0_{298.1} = -3\ 223$ (1189)

Cd (in het. amalg.) $+\ \mathrm{2HgBr + 4H_2O}$ (in satd. $\mathrm{CdBr_2.4H_2O}$) $=\ \mathrm{2Hg(l) + CdBr_2.4H_2O(s)}$

$E = 0.55916 - 0.000366(t - 18) - 0.0000046(t - 18)^2$; $E^0_{298.1} = 0.55638$; $E^0_{273.1} = 0.56426$ (1099)

$\mathrm{HgCl(s) + Br^- = HgBr(s) + Cl^-}$ (1183)

$E^0_{298.1} = 0.1274$; $\Delta F^0_{298.1} = -2\ 940 \pm 10$

$m_{(H^+)}$	$m_{(Cl^-)}$	$m_{(Br^-)}$	K_m
0.00909	0.00907	0.000084	108.5
.00781	.00747	.00013	57.5
.04429	.04390	.00019	231.1
.04005	.03988	.00011	362.5
.09994	.09631	.00317	30.4
.1092	.0824	.00087	94.7
.2021	.2012	.00190*	105.9

* Estimated by titrating the liberated I_2 with $Na_2S_2O_3$ solution.

$\mathrm{Hg^{++} + 4Br^- = HgBr_4^{--}}$

$K_{298.1} = 4.3 \times 10^{21}$ (1343)

$\mathrm{HgBr_2(aq) + 2Br^- = HgBr_4^{--}}$

$K_{298.1} = 2.8 \times 10^4$ (1343)

$\mathrm{xHgBr_2(aq) + yNH_4OH(aq)}$ = various solid phases (463)

$\mathrm{HgI(s)}$

$E^0_{298.1} = 0.5761$; $\Delta F^0_{298.1} = -13\ 290$ (1189) *from* (1481)

Pb (in het. amalg.) $+\ \mathrm{2HgI(s) = 2Hg(l) + PbI_2(s)}$

$E_{298.1} = 0.3175$ (1481); *cf.* (471)

Cd (in het. amalg.) $+\ \mathrm{2HgI(s) = 2Hg(l) + CdI_2(s)}$

$E = 0.41470 + 0.000362(t - 18) - 0.0000003(t - 18)^2$; $E^0_{298.1} = 0.41722$; $E^0_{273.1} = 0.40809$ (1099); $E = 0.41885 + 0.0003568(t - 30) + 0.0000008\ (t - 30)^2$; $E^0_{298.1} = 0.41709$; $E^0_{273.1} = 0.41065$ (1559)

$\mathrm{HgCN.2NH_3(s) = (?) + xNH_3(g)}$ (1134) (E)

T	P	T	P
278.1	0.004	303.1	0.0243
283.1	0.005	308.1	0.033
288.1	0.008	313.1	0.0454
292.1	0.008	318.1	0.059
293.1	0.0112	323.1	0.075
296.1	0.0112	328.1	0.096
298.1	0.0204	332.1	0.114

$\mathrm{Hg_2SO_4(s)}$; $\Delta F^0_{298.1} = -162\ 100$ (1183)

$\mathrm{Pb(s) + Hg_2SO_4(s) = 2Hg(l) + PbSO_4(s)}$

$E^0_{298.1} = 0.9697$ (598); *cf.* (420)

Pb (in het. amalg.) $+\ \mathrm{Hg_2SO_4(s) = PbSO_4(s) + 2Hg(l)}$

$E_{298.1} = 0.96466$; $\Delta F^0_{298.1} = -44\ 516$ (979)

Zn (in het. amalg.) $+\ \mathrm{Hg_2SO_4(s) + 6H_2O}$ (in satd. $\mathrm{ZnSO_4.6H_2O}$) $=\ \mathrm{2Hg(l) + ZnSO_4.6H_2O(s)}$ (299)

T	E*	T	E*
298.1	1.41371	318.1	1.39400
303.1	1.40952	323.1	1.38823
308.1	1.40462	328.1	1.38212
311.1	1.40143		

* Weston cell at 303.1°K = 1.0182v.

Zn (in het. amalg.) $+\ \mathrm{Hg_2SO_4(s) + 7H_2O}$ (in satd. $\mathrm{ZnSO_4.7H_2O}$) $=\ \mathrm{2Hg(l) + ZnSO_4.7H_2O(s)}$ (235, 299, 682, 683, 684, 685, 686)

T	E*	T	E*
298.1	1.41974	308.1	1.40625
303.1	1.41368	311.1	1.40147

* Weston cell at 303.1°K = 1.0182v.

Cd (in het. amalg.) $+\ \mathrm{Hg_2SO_4(s)} + \tfrac{8}{3}\mathrm{H_2O}$ (in satd. $\mathrm{CdSO_4.\tfrac{8}{3}H_2O}$) $=\ \mathrm{2Hg(l) + CdSO_4.\tfrac{8}{3}H_2O(s)}$

$E_{298.1} = 1.0183$ (224); $E = 1.0186 - 0.000038(t - 20) - 0.00000065(t - 20)^2$ (1099); *cf.* (47, 48, 50, 680, 681, 684, 685, 686, 687, 688)

$\mathrm{2Hg(l) + 2H_2SO_4(x) = Hg_2SO_4(s) + SO_2(g) + 2H_2O(g)}$ (1182)

$x_{(H_2SO_4)}$	Total P	P (pure acid)	P (acid + Hg_2SO_4)	K'	ΔF
		$T = 457.5$°K			
0.2795	4.26	2.25	2.27	10.61	−2144
		$T = 491.1$°K			
0.300	11.60	4.20		119.6	−4662
0.2795	10.44	4.87	4.80	119.6	−4662
0.2102	8.56	7.85	7.76	35.6	−3482

$K' = f^2_{(H_2O)}f_{(SO_2)}$; $\Delta F_{298.1} = 9\ 540$ ($x = 0.2795$)

Cu, Copper

$\mathrm{Cu(g)}$

$C_p = 5.0$; $\Delta H^0_{298.1} = 66\ 480$; $\Delta F^0_{298.1} = 63\ 210$ (1186)

$\mathrm{Cu(l)}$

$C_p = -4.5 + 0.008T$ (1186) *from* (1555, 1556); *see* **Cu(s) = Cu(l)**

$\mathrm{Cu(l) = Cu(g)}$

T	K	log K	I*	Lit.
2 148.1	0.0263	−1.580	24.17	(1274)
2 253.1	0.1315	−0.881	23.22	(510, 511, 512, 513)
2 298.1	0.0860	−1.066	24.97	(1274)
2 378.1	0.1631	−0.787	25.18	(1274)
2 448.1	0.275	−0.560	25.36	(1274)
2 453.1	0.338	−0.471	25.02	(510, 511, 512, 513)
2 488.1	0.395	−0.404	25.30	(1274)
2 518.1	0.532	−0.274	25.21	(1274)
2 573.1	0.988	−0.0052	25.02	(1274)
2 583.1	1.000	0	24.94	(510, 511, 512, 513)

* Calculated by Randall and Nielsen (1186) from ΔH^0_0 determined from vapor pressure data. Whence: $\Delta F^0 = 101\ 700 - 9.5T \ln T + 0.004T^2 + 25.13T$; $\Delta H^0_{298.1} = 104\ 180$; $\Delta F^0_{298.1} = 93\ 410$.

Randall and Nielsen (1186) also calculated from above for Cu(s) = Cu(g), $\Delta S^0_{298.1} = 45.95$; and from Lewis, Gibson and Latimer (868), Cu(s), $S^0_{298.1} = 8.18$; and (859) Cu(g), $S^0_{298.1} = 38.12$ (from theory of ultimate rational units); $\Delta S^0_{298.1} = 29.94$; or for Cu(l) = Cu(g), $\Delta S^0_{298.1} = 20.12$.

Using this value of $\Delta S^0_{298.1}$ and above values of the vapor pressure (1186) calculated values for ΔH^0_0 (average 62 440), and values for log P are consistent with the following equation. These values of log P are probably more reliable than the experimental values above. $\Delta H^0_0 = 62\ 240$ gives $\Delta H^0_{2414.1} = 62\ 060$ in fair agreement with $\Delta H = 66\ 900$ calculated by Hildebrand (622).

T	ΔH_0	log P
2 148.1	65 302	−1.288
2 253.1	61 374	−0.982
2 298.1	64 577	−0.862
2 378.1	63 804	−0.664
2 448.1	63 112	−0.502
2 453.1	62 211	−0.489
2 488.1	62 237	−0.414
2 518.1	61 618	−0.347
2 573.1	60 288	−0.236
2 583.1	59 902	−0.214

$\Delta F^0 = 62\ 240 - 9.5T \ln T + 0.004T^2 + 41.12T$; $\Delta H^0_{298.1} = 59\ 250$; $\Delta F^0_{298.1} = 58\ 910$. This value probably better than 93 410 above.

Cu(s)

ΔF^0, $\Delta H^0 = 0$ (853, 873); $C_p = 5.46 + 0.0072T$ (1186) *from* (346, 1043, 1333, 1555, 1556)

Cu(s) = Cu(g); *see* Cu(l) = Cu(g)

Cu(s) = Cu(l)

$\Delta F^0 = 9\ 895 + 9.96T \ln T - 0.0034T^2 - 74.52T$; $\Delta F^0_{298.1} = 4\ 300$; $\Delta H^0_{298.1} = 7\ 228$ (1186) *from* (492, 1215, 1555, 1556)

Cu^{++}

$E^0_{298.1} = -0.3448$; $\Delta F^0_{298.1} = 15\ 912$ (885) *from* (873)

Cu(s) = Cu (in het. amalg.) (297, 471, 1067, 1093, 1099)

CuO(s)

$\Delta F^0 = -37\ 280 + 0.39T \ln T - 0.0027T^2 + 21.981T$; $\Delta H^0_{298.1} = 37\ 160$; $\Delta F^0_{298.1} = -30\ 300$ (1186)

CuO(s) = CuO(l)

$\Delta F^0 = 13\ 300 - 8.264T$; $\Delta F^0_{1609} = 0$; $\Delta F^0_{298.1} = 10\ 836$ (1186)

$Cu^{++} + H_2O(l) = Cu(OH)^+ + H^+$

c	% Hydrolysis in $CuCl_2$(aq) (800)	
	358.6°K	373.1°K
0.00392	0.515	0.888
.0157	.375	.612
.0625	.276	.407
.25	.252	.313
	In $Cu(NO_3)_2$(aq) (800)	
0.00392	0.660	1.02
.0156	0.530	0.648
.0625		0.368
.248		0.231

$CuO(s) + OH^- = HCuO_2^-$ (1023, 1024)

$Cu(OH)_2$(s)

$\Delta F^0_{298.1} = -85\ 090$ (1186) *from* (13)

$Cu(OH)_2(s) = CuO(s) + H_2O(g)$ (E)

$P_{298.1} = 0.0001$(13); $= 0.0011$ (430)

$Cu(OH)_2(s) + OH^- = HCuO_2^- + H_2O(l)$ (1023, 1024)

CuCl(s); $\Delta F^0_{298.1} = -28\ 440$ (1186)

$\frac{1}{2}H_2(g) + CuCl(s) = Cu(s) + H^+ + Cl^-$ (1085)

T	$m_{(HCl)}$	*E*
298.1	0.01447	0.34718
308.1	.01447	.34643
298.1	.04304	.29227
288.1	.09596	.25340
298.1	.09596	.25204
308.1	.09596	.25049
288.1	.1876	.22134
298.1	.1876	.21911
308.1	.1876	.21663
298.1	.3253	.19158
308.1	.3253	.18823
298.1	.6310	.15798

T.	288.1	298.1	308.1
E^0.	0.1274	0.1216	0.1156

$CuCl(s) + \frac{1}{2} H_2(g) = Cu(s) + HCl(g)$ (40, 1109, 1213, 1214)

$Bi(s) + 3CuCl(s) + H_2O(l) = 3Cu(s) + BiOCl(s) + 2H^+ + 2Cl^-$

At 298.1°K (1390)

$c_{(\Sigma Cl)}$	$c_{(\Sigma Cu)}$	$c_{(\Sigma Bi)}$
0.977	0.0499	0.0615
1.939	.0642	.2640
0.594	.0345	.0117
0.594	.0341	.0114
0.537	.0239	.0087
0.902	.0468	.0484
0.818	.0456	.0449
1.243	.0560	.1075
1.176	.0543	.0958
0.258	.0171	Trace
0.229	.0134	Trace

At 348.1°K (1085)

$K_{348.1} = 2.10 \times 10^{-3}$; $\Delta H = -7\ 390$

$c_{(\Sigma Cl)}$	$c_{(\Sigma Cu)}$	$c_{(\Sigma Bi)}$	$c_{(\Sigma H)}$
0.4059	0.0762	0.0033	0.3198
.4186	.0781	.0044	.3273
.4087	.0769	.00225	.3251
.4079	.0765	.00196	.3255

$CuCl.NH_3(s) = CuCl(s) + NH_3(g)$ (108) (E)

T	*P*	*T*	*P*
305.8	0.000047	349.4	0.00186
336.0	0.00066	417.6	0.132 (extrap.)
	$\Delta H = 16\ 730$		

$CuCl.1\frac{1}{2}NH_3(s) = CuCl.NH_3(s) + \frac{1}{2}NH_3(g)$ (108) (E)

T	*P*	*T*	*P*
305.8	0.033	349.4	0.532
336.0	0.241	$\Delta H = 6\ 305$	

$CuCl.3NH_3(s) = CuCl.1\frac{1}{2}NH_3(s) + 1\frac{1}{2}NH_3(g)$ (108, 385); *cf.* (903, 1134) (E)

T	*P*	*T*	*P*
273.1*	0.078	307.6	0.568
286.1*	0.158	315.3	0.822
288.1	0.200	317.6	0.928
301.6	0.421	318.1	0.949
305.8*	0.450	320.1	1.034
	$\Delta H = 14\ 220$*		

* From (108); all other values from (385).

$2CuCl_2(s) = 2CuCl(s) + Cl_2(g)$ (973)

T	*P*	*T*	*P*
739.4	0.1374	774.1	0.5032
769.4	.3937		

$CuCl_2.2H_2O(s) = CuCl_2.H_2O(s) + H_2O(g)$ (331, 847) (E)

T	*P*	*T*	*P*
291.0	0.0049	333.1*	0.120
299.7	0.0114	337.28	0.1389
304.5	0.0154	338.1*	0.153
312.9	0.0247	343.1*	0.200
326.64	0.0714	353.1*	0.322

* From (847); all other values from (331).

$CuCl_2.3H_2O(s)$* $= CuCl_2.2H_2O(s) + H_2O(g)$ (847) (E)

T	*P*	*T*	*P*
353.1	0.082	373.1	0.243
363.1	0.141		

* The existence of the trihydrate is questionable.

$CuCl_2.2NH_3(s) = (?) + xNH_3(g)$ (E)

$P_{543.1} = 1.000$ (387)

$3CuCl_2.10NH_3(s) = 3(CuCl_2.2NH_3)(s) + 4NH_3(g)$ (E)

$P_{397.1} = 0.938$ (387)

$3(CuCl_2.5NH_3)(s) = 3CuCl_2.10NH_3(s) + 5NH_3(g)$ (379) (E)

T	P	T	P
336.6	0.150	368.5	0.668
344.6	0.237	373.1	0.804
351.6	0.332	377.6	0.964
358.1	0.425	378.1	1.000
361.6	0.500	$\Delta H = 68\ 000$	

$CuCl_2.6NH_3(s) = (?)$ (Solid solution) $+ xNH_3(g)$ (387) (E)

Moles NH_3	T at which $P = 0.938$	Moles NH_3	T at which $P = 0.938$
5.76	289.1	5.17	353.1
5.49	323.1	5.13	363.1
5.23	343.1	5.08	376.1

$CuCl_2.4NH_2CH_3(s) = (?) + xNH_2CH_3(g)$ (393) (E)

T	P	T	P
323.6	0.086	372.1	0.645
337.6	0.141	381.6	0.888
355.6	0.306	385.6	1.026
364.1	0.454	$\Delta H = 13\ 770x$	

$CuCl(s) + Cl^- = CuCl_2^-$ (1085); *cf.* (142, 143)

In HCl(aq) at 298.1°K

$c_{(HCl)}$	$c_{(\Sigma Cl)}$	$c_{(\Sigma Cu)}$	K_c	$\mu_c^{1/2}$
1.1650	1.2815	0.1165	0.1111	1.080
0.3165	0.3365	.01988	.0671	0.562
.2156	.2290	.01340	.0662	.464
.0978	.1038	.00595	.0650	.313

$Cu(ClO_3)_2.4NH_3(s) = (?) + xNH_3(g)$ (391) (E)

T	P	T	P
370.1	0.047	420.1	0.592 (extrap.)
389.1	0.072	424.1	0.717 (extrap.)
415.5	0.461	431.1	1.000 (extrap.)
	$\Delta H = 15\ 600x$		

$Cu(ClO_3)_2.6NH_3(s) = (?) + xNH_3(g)$ (E)

$P_{284.1} = 0.938$; $\Delta H = 9\ 800x$; solid solution results upon decomposition (391)

$Cu(ClO_4)_2.4NH_3(s) = (?) + xNH_3(g)$ (1290) (E)

T	P	T	P
387.1	0.0143	462.1	0.0518
399.1	0.016	467.1	0.062
422.1	0.0182	484.1	0.101
431.1	0.0230	498.1	0.237
439.1	0.0267	543.1	1.000*
452.1	0.0431	$\Delta H = 20\ 000x$	

* Extrapolated from (390).

$Cu(ClO_4)_2.6NH_3(s) = (?) + xNH_3(g)$ (E)

$P_{330.1} = 1.000$; $\Delta H = 11\ 600x$; solid solution upon decomposition (390)

$Cu(ClO_4)_2.8(?)H_2O(s) = Cu(ClO_4)_2.4H_2O(s) + 4(?)H_2O(g)$ (1290) (E)

T*	P	T*	P
355.1	0.0129	421.1	0.0216
366.1	0.0187	456.1	0.0216
400.1	0.0187	462.1	0.0274
411.1	0.0201	472.1	0.0792

* At 373.1°, changes into the tetrahydrate; at 420.1° basic salt forms; at 456.1° decomposition begins.

$CuBr.NH_3(s) = CuBr(s) + NH_3(g)$ (108) (E)

T	P	T	P
317.1	0.0033	349.9	0.041
336.4	0.017	359.1	0.132 (extrap.)
	$\Delta H = 14\ 640$		

$CuBr.1\frac{1}{2}NH_3(s) = CuBr.NH_3(s) + \frac{1}{2}NH_3(g)$ (108) (E)

T	P	T	P
306.1	0.013	349.9	0.230
336.4	0.118	371.1	0.774
	$\Delta H = 6\ 575$		

$CuBr.3NH_3(s) = CuBr.1\frac{1}{2}NH_3(s) + 1\frac{1}{2}NH_3(g)$ (108, 385) (E)

T	P	T	P
283.1	0.132*	306.1	0.442
285.1	0.151	313.6†	0.684
286.5†	0.158	317.1	0.733
296.1	0.263*	322.1†	0.974
305.1†	0.434	$\Delta H = 14\ 250$	

* Interpolated. † From (385); all other values from (108).

$2CuBr_2(s) = 2CuBr(s) + Br_2(g)$ (676)

T	P	T	P
439.1	0.0041	523.1	0.2447
453.2	.0089	539.4	.4651
486.1	.0474	554.1	.8085
505.4	.1118		

$CuBr_2.2NH_3(s) = (?) + xNH_3(g)$ (E)

$P_{533.1} = 0.938$ (387)

$3CuBr_2.10NH_3(s) = 3(CuBr_2.2NH_3)(s) + 4NH_3(g)$ (E)

Freshly prepared substance, $P_{439.1} = 0.938$; previously heated substance, $P_{428.1} = 0.938$ (387)

$3(CuBr_2.5NH_3)(s) = 3CuBr_2.10NH_3(s) + 5NH_3(g)$ (397); *cf.* (386) (E)

T	P	T	P
296.1	0.007	377.6	0.618
331.1	0.072	382.9	0.766
345.6	0.151	387.6	0.895
357.1	0.259	392.1	1.037
369.6	0.421	$\Delta H = 70\ 000$	

$CuBr_2.6NH_3(s) = (?)$ (Solid solution) $+ xNH_3(g)$ (387) (E)

Moles NH_3 in substance	T at which $P = 0.938$	Moles NH_3 in substance	T at which $P = 0.938$
6.04	273.1	5.28	354.1
5.89	288.1	5.19	364.1
5.82	305.1	5.15	376.1
5.65	324.1	5.08	388.1
5.48	338.1		

$CuBr_2.4NH_2CH_3(s) = (?) + xNH_2CH_3(s)$ (393) (E)

T	P	T	P
337.6	0.079	379.1	0.618
349.6	0.191	384.6	0.776
362.6	0.330	392.6	1.019
372.1	0.476	396.1	1.138
	$\Delta H = 14\ 000x$		

$CuI(s) + \frac{1}{2}I_2(aq) = Cu^{++} + 2I^-$ (174, 413, 1342)

$CuI.\frac{1}{2}NH_3(s) = CuI(s) + \frac{1}{2}NH_3(g)$ (108) (E)

T	P	T	P
371.1	0.047	409.1	0.370
382.1	0.0769	$\Delta H = 7\ 610$	

$CuI.NH_3(s) = CuI.\frac{1}{2}NH_3(s) + \frac{1}{2}NH_3(g)$ (108) (E)

T	P	T	P
349.7	0.039	382.1	0.228
371.1	0.124	$\Delta H = 7\ 350$	

$CuI.2NH_3(s) = CuI.NH_3(s) + NH_3(g)$ (108) (E)

T	P	T	P
281.1	0.037	305.9	0.213
286.1	0.055	317.1	0.426
	$\Delta H = 11\ 300$		

$CuI.3NH_3(s) = CuI.2NH_3(s) + NH_3(g)$ (108, 385); *cf.* (903) (E)

T	P	T	P
263.1*	0.025	305.9*	0.425
285.9*	0.121	316.6	0.739
290.1	0.174	322.1	0.961
303.3	0.371	$\Delta H = 10\ 370$*	

* From (108); all other values from (385).

$3CuI_2.10NH_3(s) = 3(CuI_2.2NH_3)(s) + 4NH_3(g)$ (E)

$P_{420.1} = 0.938$ (387)

$3(CuI_2.5NH_3)(s) = 3CuI_2.10NH_3(s) + 5NH_3(g)$ (E)

$P_{392.6} = 0.938$; $\Delta H = 41\ 000$ (387)

$CuI_2.5NH_3(s) = (?)$ (Solid solution) $+ xNH_3(g)$ (390) (E)

T	P	T	P
329.1	0.061	371.1	0.395
349.1	0.129	379.1	0.563
359.1	0.205	386.6	0.758
363.1	0.262	393.1	0.991
366.1	0.313		

$CuI_2.6NH_3$ (E)

Ephraim (387) gives $P = 0.94$ at *ca.* 303°K

$CuI_2.4NH_2CH_3(s) = (?) + xNH_2CH_3(g)$ (393) (E)

T	P	T	P
330.1	0.092	385.6	0.641
340.6	0.138	392.1	0.816
349.6	0.184	397.6	1.000
361.6	0.267	402.6	1.182
376.1	0.454	$\Delta H = 14\ 240$x	

$Cu(IO_3)_2.5NH_3(s) = Cu(IO_3)_2.4NH_3(s) + NH_3(g)$ (391) (E)

T	P	T	P
323.6	0.186	355.1	0.842
338.1	0.342	357.6	0.946
348.1	0.579	$\Delta H = 12\ 700$	

CuS

$C_p = 12.03 + 0.001T$ (158, 1186); $\Delta F^0 = -12\ 120 - 2.45T \ln T + 0.0025T^2 + 14.89T$; $\Delta H^0_{298.1} = -11\ 610$; $\Delta F^0_{298.1} = -11\ 620$ (158)

$CuSO_4(s)$

$C_p = 24.09$ (1325); $\Delta F^0 = -182\ 360 + 0.8T \ln T + 84.322T$; $\Delta H^0_{298.1} = -182\ 600$, $\Delta F^0_{298.1} = -155\ 850$ (1186)

$CuSO_4.H_2O(s)$

$C_p = 31.08$ (1325); $\Delta F^0 = 256\ 360 + 3.24T \ln T + 0.00165T^2 - 0.00000037T^3 + 114.418T$; $\Delta H^0_{298.1} = -257\ 460$; $\Delta F^0_{298.1} = -216\ 610$ (1186)

$CuSO_4.3H_2O(s)$

$C_p = 48.88$ (1325); $\Delta F^0 = -398\ 600 + 5.12T \ln T + 0.00495T^2 - 0.00000111T^3 + 194.448T$; $\Delta H^0_{298.1} = -400\ 520$; $\Delta F^0_{298.1} = -331\ 530$ (1186)

$CuSO_4.H_2O(s) = CuSO_4(s) + H_2O(g)$

$\Delta F^0 = 16\ 590 - 1.5T \ln T - 26.125T$ (range 298 to 493°K); $\Delta H^0_{298.1} = 17\ 040$; $\Delta F^0_{298.1} = 6\ 255$ (1186) *from* (430, 843, 844, 1325, 1350)

$CuSO_4.3H_2O(s) = CuSO_4.H_2O(s) + 2H_2O(g)$

$\Delta F^0 = 27\ 420 - 72.190T$ (range 298 to 373°K); $\Delta F^0_{298.1} = 5\ 900$ (1186) *from* (257, 458, 843, 844)

$CuSO_4.5H_2O(s)$

$C_p = 67.15$ (1325); $\Delta F^0 = -539\ 970 + 7.00T \ln T + 0.00825T^2 - 0.00000185T^3 + 273.164T$; $\Delta H^0_{298.1} = -542\ 710$; $\Delta F^0_{298.1} = -445\ 960$ (1186)

$ZnSO_4.7H_2O$ and $CuSO_4.5H_2O$ (mixed crystals) $= (?) + xH_2O(g)$ (641) (E)

Mole % $ZnSO_4$	P at which $T = 293.1 \pm 0.2°$	Mole % $ZnSO_4$	P at which $T = 293.1 \pm 0.2°$
Rhombic ($7H_2O$)		Triclinic ($5H_2O$)	
100.0	0.0138	11.6	0.0050
97.8	0.0129	2.8	0.0063
		0.0	0.0076
Monoclinic ($7H_2O$)			
74.6	0.0122		
64.7	0.0123		

$CuSO_4.5H_2O(s) = CuSO_4.3H_2O(s) + 2H_2O(g)$

$\Delta F^0 = 26\ 550 - 70.876T$ (range 283 to 373°K); $\Delta F^0_{298.1} = 5\ 420$ (1186) *from* (257, 430, 458, 641, 843, 844, 895, 1090, 1113, 1114, 1335, 1531)

Cu (in het. amalg.) $+ Hg_2SO_4(s) + 5H_2O$ (in satd. $CuSO_4.5H_2O$) $= 2Hg(l) + CuSO_4.5H_2O(s)$

$\Delta H_{298.1} = -24\ 710$; $\Delta F_{298.1} = -15\ 995$ (1186) *from* (297, 1093, 1099)

$CuSO_4.4NH_3(s) = CuSO_4.2NH_3(s) + 2NH_3(g)$ (380) (E)

T	P	T	P
393.1	0.082	433.6	0.661
410.1	0.162	439.6	0.875
424.6	0.421	441.6	0.948

$\Delta H = 32\ 160$ (380); $P_{414.6} = 0.938$ (387)

$CuSO_4.5NH_3(s) = CuSO_4.4NH_3(s) + NH_3(g)$ (380, 387) (E)

T	P	T	P
293.1	0.004	368.1	0.761
343.1	0.162	373.1	0.949
360.6	0.470	$\Delta H = 12\ 830$	

$CuS_2O_3.4NH_3(s) = (?) + xNH_3(g)$ (390) (E)

T	P	T	P
339.1	0.136	354.1	decomposes
350.1	0.155		

$CuS_2O_6.4NH_3(s) = (?) + xNH_3(g)$ (390) (E)

T	P	T	P
385.1	0.032	457.1	0.110
422.1	0.045	523.1	1.000 (extrap.)
444.1	0.054	$\Delta H = 19\ 300$x	

$CuS_2O_6.5NH_3(s) = CuS_2O_6.4NH_3(s) + NH_3(g)$ (390) (E)

T	P	T	P
253.1	0.079	282.1	0.462
260.1	0.149	287.1	0.599
264.1	0.188	292.1	0.770
269.1	0.241	299.1	1.045
274.1	0.312	$\Delta H = 10\ 400$	

$CuS_4O_6.4NH_3(s) = (?) + xNH_3(g)$ (390) (E)

T	P	T	P
293.6	0.007	355.1	0.316
323.1	0.115	362.1	0.632
338.1	0.154	366.1	0.991

$\Delta H = 13\ 000x$

$Cu(NO_3)_2(aq) = (?) + xH_2O(g)$ (849) (E)

$Cu(NO_3)_2.4NH_3(s) = Cu(NO_3)_2.2NH_3(s) + 2NH_3(g)$ (387, 390) (E)

T	P	T	P
416.1	0.086	448.6	0.336
426.6	0.112	479.1	1.000
437.6	0.207	$\Delta H = 34\ 800$	

$Cu(NO_3)_2.6NH_3(s) = Cu(NO_3)_2.4NH_3(s) + 2NH_3(g)$ (646) (E)

T	P	T	P
236.6	0.029	288.5*	0.996
237.1	0.046	288.9	0.997
256.6	0.158	296.5	1.282
263.7	0.316	302.4	1.572
270.6	0.509	308.5	1.908
271.6	0.514	316.5	2.500
281.0	0.722	323.6	3.088

* According to (387), $P_{288.1} = 0.938$.

$CuOH(s) + 2NH_4OH(aq) = Cu(NH_3)_2^+ + OH^- + H_2O(l)$ (349)

$2CuP_2(s) = 2Cu(s) + P_4(g)$ (507)

T	P	T	P
718.1	0.0097	793.1	0.1226
728.1	.0150	803.1	.1237
758.1	.0180	843.1	.1313
768.1	.0218		

$CuC_2O_4.5NH_3(s) = CuC_2O_4.2NH_3(s) + 3NH_3(g)$ (387, 390) (E)

T	P	T	P
294.1	0.387	310.1	0.938
300.1	0.576	311.1	1.037
305.1	0.786		

$Cu(HCO_2)_2.4NH_3(s) = (?) + xNH_3(g)$ (390) (E)

T	P	T	P
260.1	0.012	293.1	0.087
268.1	0.020	301.1	0.129
271.1	0.025	309.1	0.242
284.1	0.054	332.1	1.000 (extrap.)

$\Delta H = 11\ 700x$; at 310° the compound changes into another form

$Cu(CNS)_2.4NH_3(s) = (?)$ (Solid solution) $+ xNH_3(g)$ (387) (E)

Moles NH_3	T at which $P = 0.938$	Moles NH_3	T at which $P = 0.938$
4.00	373.1	2.23	388.1
2.55	381.1	2.00	400.1 (decomposes)

$Cu(CNS)_2.5NH_3(s) = Cu(CNS)_2.4NH_3(s) + NH_3(g)$ (E)

$P_{276.1} = 0.938$ (387)

$Cu(CNS)_2.{>}5NH_3(s) = (?)$ (Solid solution) $+ xNH_3(g)$ (387, 390) (E)

Moles NH_3	T at which $P = 0.938$	Moles NH_3	T at which $P = 0.938$
5.50	255.1	5.05	266.1
5.16	260.1		

$Cu(CH_3CO_2)_2.4NH_3(s) = Cu(CH_3CO_2)_2.2NH_3(s) + 2NH_3(g)$ (390) (E)

T	P	T	P
273.1	0.007	331.1	0.437
297.6	0.059	338.1	0.572
310.1	0.130	346.1	0.812
317.1	0.207	348.1	0.938 (387)
324.1	0.312	351.1	1.013

$Cu(C_6H_5SO_3)_2.5NH_3(s) = Cu(C_6H_5SO_3)_2.4NH_3(s) + NH_3(g)$ (E)

$P = 1.000$ at room temperature (383)

$Cu(C_6H_5CO_2)_2.2NH_3(s) = (?) + xNH_3(g)$ (383) (E)

T	P	T	P
396.1	0.067	453.1	0.856
426.1	0.230	456.1	1.000 (decomposes)
448.1	0.618		

$Cu(C_6H_5CO_2)_2.3.77NH_3(s) = (?)$ (Solid solution) $+ xNH_3(g)$ (383); *cf.* (387) (E)

T	P	T	P
317.1	0.099	345.1	0.629
328.1	0.237	354.1	0.928
339.1	0.466	355.6	1.000

$Cu(C_6H_5CO_2)_2.5.74NH_3(s) = (?)$ (Solid solution) $+ xNH_3(g)$ (383); *cf.* (387) (E)

T	P	T	P
266.1	0.188	285.1	0.888
273.1	0.436	285.6	0.912
275.1	0.483	287.1	1.000
278.1	0.591		

$Cu(C_6H_5CO_2)_2.mNH_3(s) = (?) + xNH_3(g)$ (387) (E)

Moles NH_3	T at which $P = 0.938$	Moles NH_3	T at which $P = 0.938$
8.32	260.1	4.08	323.1
8.27	268.1	4.05	343.1
5.99	273.1	3.77	355.1
5.85	282.1	2.31	362.1
5.74	289.1	2.15	371.1
4.12	293.1	2.10	400.1
4.10	305.1	2.08	443.1

At a pressure of 0.938 the octammine is stable at 270.1°K; at a little above 270.1°K, the hexammine is stable.

Solid soln., Moles NH_3	T	Solid soln., Moles NH_3	T
6 –5.74	270.1–288.1	4 –3.77	351.1–354.1
5.74–4.12	288.1–293.1	3.77–2.31	354.1–361.1
4.12–4	293.1–351.1	2.31–2.0	361.1–453.1

Cu salt of α-naphthoylbenzoic acid $+ 8NH_3$ (383) (E)

T	P	T	P
266.1	0.192	281.6	0.487
268.1	0.237	285.1	0.632
272.1	0.309	289.1	0.855
277.1	0.408	289.1	0.968

Cu salt of naphthalene-2-sulfonic acid $+ 6NH_3$ (383, 384) (E)

T	P	T	P
339.1	0.599	352.1	0.963
346.1	0.780	352.6	1.000

Cu salt of naphthalene-2-sulfonic acid $+ 8NH_3$ (E)

$P_{272.1} = 1.000$ (383, 384); for ammoniates of Cu salts of sulfanilic, phthalic, trinitrobenzoic, naphthalic, naphthalene-1-sulfonic, dibromonaphthalene-2-sulfonic acids, *see* (383, 384)

$\mathbf{2CuO(s) = Cu_2O(s) + \frac{1}{2}O_2(g)}$

$\Delta F^0 = 33\ 550 - 0.95T \ln T + 0.00375T^2 - 22.340T$ (range 1111 to 1358°K); $\Delta H^0_{298.1} = 33\ 510$; $\Delta F^0_{298.1} = 25\ 610$ (1186) *from* (431, 1229, 1391, 1537)

$\mathbf{Cu_2O(s)}$

$\Delta F^0 = -41\ 150 - 0.17T \ln T - 0.0033T^2 + 22.583T$; $\Delta H^0_{298.1} = -40\ 810$; $\Delta F^0_{298.1} = -35\ 000$ (1186)

$\mathbf{Cu_2O(s) = 2Cu(s) + \frac{1}{2}O_2(g)}$

$\Delta F^0 = 41\ 150 + 0.17T \ln T + 0.0033T^2 - 22.583T$; $\Delta H^0_{298.1} = 40\ 810$; $\Delta F^0_{298.1} = 35\ 000$ (1186)

$\mathbf{Cu_2O(s) = 2Cu(l) + \frac{1}{2}O_2(g)}$ (1186) *from* (1229)

$\Delta F^0 = 60\ 940 + 20.09T \ln T - 0.0035T^2 - 171.6T$; $\Delta H^0_{298.1} = 55\ 270$; $\Delta F^0_{298.1} = 43\ 600$

T	P	xT	K
1 392.3	0.0000368	0.975	0.00577
1 423.5	0.0000460	0.965	0.00632
1 457.7	0.0000540	0.953	0.00666

$\mathbf{2CuO(s) = Cu_2O(l) + \frac{1}{2}O_2(g)}$ (1186) *from* (1391)

$\Delta F = 51\ 950 - 0.95T \ln T + 0.00375T^2 - 34.533T$ (range 1356 to 1505°K); $\Delta H^0 = 51\ 900$; $\Delta F^0_{298.1} = 40\ 410$

$\mathbf{2CuO(l) = Cu_2O(s) + \frac{1}{2}O_2(g)}$

$\Delta F^0 = 6\ 950 - 0.95T \ln T + 0.00375T^2 - 5.812T$ (range 1357 to 1506°K); $\Delta H = 6\ 900$; $\Delta F^0_{298.1} = 3\ 938$ (1186) *from* (1391)

$\mathbf{Cu_2O(s) + H_2(g) = 2Cu(s) + H_2O(g)}$

$K_{723.1} = 16.7$ to 19.0 (1538)

$\mathbf{2CuO(s) + H_2(g) = Cu_2O(s) + H_2O(g)}$

$K_{723.1} = 26.3$ to 30.1 (1538); *cf.* (304, 491)

$\mathbf{3Cu(s) + CuSO_4(s) = 2Cu_2O(s) + SO_2(g)}$

$\Delta F^0 = 32\ 400 - 53.614T$ (range 525 to 588°K); $\Delta F^0_{298.1} = 16\ 420$ (1186) *from* (1310)

$\mathbf{Cu_2O(s) = Cu_2O(l)}$

M.P. = 1236°C; $\Delta F^0 = 18\ 400 - 12.193T$; $\Delta F^0_{298.1} = 14\ 760$; $\Delta H = 18\ 400$ (1186)

$\mathbf{Cu_2S(\alpha)}$

$C_p = 6.75 + 0.039T$; $\Delta F^0 = -17\ 920 + 8.29T \ln T - 0.0160T^2 - 46.46T$; $\Delta H^0_{298.1} = -18\ 970$; $\Delta F^0_{298.1} = -19\ 110$ (1186) *from* (75)

$\mathbf{3CuS(s) + CuSO_4(s) = 2Cu_2S(\alpha) + 2SO_2(g)}$

$P_{368.1} = 0.2368$; $\Delta F^0 = 46\ 940 + 6.17T \ln T - 158.25T$; $\Delta H^0_{298.1} = 45\ 100$; $\Delta F^0_{298.1} = 10\ 245$ (1186) *from* (1204)

$\mathbf{Cu_2S(\beta)}$

$C_p = 20.45 + 0.0145T$; $\Delta F^0 = -20\ 440 - 5.41T \ln T - 0.0037T^2 + 36.86T$; $\Delta H^0_{298.1} = -18\ 500$; $\Delta F^0_{298.1} = -18\ 970$ (1186) *from* (75)

$\mathbf{4CuS(s) = 2Cu_2S(\beta) + S_2(g)}$

$\Delta F^0 = 38\ 160 + 0.72T \ln T - 0.013T^2 - 39.56T$ (range 666 to 775°K); $\Delta H^0_{298.1} = 39\ 100$; $\Delta F^0_{298.1} = 26\ 820$ (1186) *from* (12, 1158, 1508)

$\mathbf{3CuS(s) + CuSO_4(s) = 2Cu_2S(\beta) + 2SO_2(g)}$

$\Delta F^0 = 41\ 890 - 6.37T \ln T - 55.25T$ (range 394 to 448°K); $\Delta H^0_{298.1} = 43\ 730$; $\Delta F^0_{298.1} = 14\ 600$ (1186) *from* (1204)

$\mathbf{2Cu_2O(s) + Cu_2S(\beta) = 6Cu(s) + SO_2(g)}$

$\Delta F^0 = 34\ 480 + 9.37T \ln T + 0.0063T^2 - 105.212T$ (range, 781 to 1324°K); $\Delta H^0_{298.1} = 31\ 130$; $\Delta F^0_{298.1} = 19\ 590$ (1186) *from* (1204, 1310, 1412)

$\mathbf{2CuSO_4(s) + Cu_2S(\beta) = 2Cu_2O(s) + 3SO_2(g)}$

$\Delta F^0 = 99\ 280 + 13.37T \ln T - 233.52T$ (range 433 to 673°K); $\Delta H^0_{298.1} = 95\ 290$; $\Delta F^0_{298.1} = 52\ 370$ (1186) *from* (1204, 1310)

$\mathbf{CuO.CuSO_4(s) = 2CuO(s) + SO_3(g)}$

$\Delta F^0 = 53\ 970 + 1.25T \ln T - 54.617T$ (range 1013 to 1093°K); $\Delta H^0_{298.1} = 54\ 010$; $\Delta F^0_{298.1} = 39\ 810$ (1186) *from* (1204)

$\mathbf{Cu_2S(\alpha) = Cu_2S(\beta)}$

$\Delta F^0_{376.1} = 0$; $\Delta H^0_{376.1} = 896$; $\Delta F^0 = -2\ 520 - 13.7T \ln T + 0.0123T^2 + 83.32T$; $\Delta H^0_{298.1} = 470$; $\Delta F^0_{298.1} = 140$ (1186) *from* (75)

$\mathbf{CuO.CuSO_4(s)}$

$\Delta H^0 = -219\ 090$ (1186) *from* (1204); $\Delta F^0 = -219\ 090 - 0.37T \ln T + 112.31T$; $\Delta H^0_{298.1} = -218\ 980$; $\Delta F^0_{298.1} = -186\ 240$ (1186)

$\mathbf{2CuSO_4(s) = CuO.CuSO_4(s) + SO_3(g)}$

$\Delta F^0 = 55\ 080 + 1.25T \ln T - 58.546T$ (range 953 to 1053°K); $\Delta H^0_{298.1} = 55\ 120$; $\Delta F^0_{298.1} = 39\ 750$ (1186) *from* (1204); *cf.* (455, 636, 835)

$\mathbf{CuO.CuSO_4(s) + Cu_2O(s) = 4CuO(s) + SO_2(g)}$

$\Delta F^0 = 43\ 020 - 40.676T$ (range 917 to 1027°K); $\Delta F^0_{298.1} = 30\ 895$ (1186) *from* (1204)

$\mathbf{4CuSO_4(s) + Cu_2O(s) = 3(CuO.CuSO_4)(s) + SO_2(g)}$

$\Delta F^0 = 45\ 240 - 48.673T$ (range 825 to 921°K); $\Delta F^0_{298.1} = 30\ 730$ (1186) *from* (1204)

$\mathbf{CuCO_3.Cu(OH)_2}$ **(malachite)** $\mathbf{+ 3H_2CO_3(aq) = 2Cu^{++} + 4HCO_3^- + 2H_2O(l)}$ (1191) *from* (448); *cf.* (564, 1147)

$\log p.f._{303.1} = 2.316$; $\Delta F^0_{303.1} = 19\ 285$; $\Delta H = -9\ 200$; $K_{298.1} = 1.64 \times 10^{-14}$; $\Delta F^0_{298.1} = 18\ 815$

$m_{(H_2CO_3)}$	$m_{(Cu^{++})}$	$m_{(NaCl)}$	$\mu^{1/2}$	$\log (1/K_m^{1/6})$
0.00338	0.000131		0.019	2.4465
.00598	.000215		.025	2.3553
.00751	.000267		.028	2.3106
.01630	.000404		.035	2.2990
.01890	.000440		.036	2.2941
.02110	.000489		.038	2.2722
.02558	.000531		.040	2.2782
.02703	.000548		.041	2.2765
.02804	.000555		.041	2.2790
.03431	.000625		.043	2.2711
.03107	.000598	0.000171	.044	2.2687
.00482	.000241	.00171	.049	2.2588
.02555	.000551	.000856	.050	2.2618
.01923	.000461	.00171	.056	2.2770
.02254	.000550	.00171	.058	2.2350
.02936	.000559	.00171	.058	2.2860
.03575	.000583	.00171	.059	2.3102
.02766	.000614	.00857	.102	2.2320
.02796	.000924	.1729	.420	2.0574

Ag, Silver

Ag(s); $\Delta H^0 = 0$; $\Delta F^0 = 0$ (853, 885, 1195)

Ag^+; $E^0_{298.1} = -0.7995$; $\Delta F^0_{298.1} \doteq 18\ 448$ (885) *from* (853, 1079)

$\mathbf{2Hg(l) + 2Ag^{++} = 2Ag(s) + Hg_2^{++}}$ (1095, 1096)

$\mathbf{4Ag(s) + 4HCl(g) + O_2(g) = 4AgCl(l) + 2H_2O(g)}$

$K_{1173.1} = 0.15 \times 10^{14}$; $K_{1273.1}$ for liquid Ag $= 0.29 \times 10^{12}$ (161)

$\mathbf{2Ag(s) + 2HCl(g) = 2AgCl(l) + H_2(g)}$

$\Delta F^0 = -8\ 560 - 0.9T \ln T + 0.00005T^2 + 22.44T$ (161) *from* (739, 740, 741, 742)

T	K	T	K
799	0.044	978	0.018
878	.030		

$\mathbf{AgCl(l) = AgCl(g)}$

$\log P$ (1200–1400°K) $= -7\ 625/T + 3.651$ (161)

$\mathbf{AgCl(s)}$

$E^0_{298.1} = 1.1363$; $\Delta F^0_{298.1} = -26\ 220 \pm 5$ (1189) *from* (470); *cf.* (888, 1195, 1548)

$\mathbf{Ag(s) + \frac{1}{2}Cl_2(g)}$ **(1 atm. actual)** $\mathbf{= AgCl(s)}$

$E = 1.1511 - 0.000595t$; $E_{298.1} = 1.1362$ (470). $E = 1.1451 - 0.000672t$; $E_{298.1} = 1.1284$ (1548)

$\frac{1}{2}H_2(g) + AgCl(s) = Ag(s) + H^+ + Cl^-$

$E^0_{298.1} = 0.2234$; $\Delta F^0_{298.1} = -5155$ (885). $E^0_{298.1} = 0.2221$; $\Delta F^0_{298.1} = -5125$ (1195) (revised value) *from* (527, 581, 582, 584, 648, 900, 1072, 1081, 1299, 1300)

$Pb(s) + 2AgCl(s) = 2Ag(s) + PbCl_2(s)$

$E^0_{298.1} = 0.4905$ (193); $E^0 = 0.49493 - 0.000189t$; $E^0_{298.1} = 0.49019$ (470); $E^0 = 0.4915 - 0.00012t$; $E^0_{298.1} = 0.4885$ (530); $E^0 = 0.4958 - 0.000124t$; $E^0_{298.1} = 0.4927$ (amorphous and fused AgCl) (792)

Pb (in het. amalg.) + $2AgCl(s) = 2Ag(s) + PbCl_2(s)$

$E_{298.1} = 0.4833$ (stick lead "amalgamated") (14); $E_{298.1} = 0.4841$ (plated Ag and AgCl) (256); $E_{298.1} = 0.48941 - 0.000203t$; $E_{298.1} = 0.48433$ (470)

Pb (amalg., $x_2 = 0.00697$) + $2AgCl(s) = PbCl_2(s) + 2Ag(s)$

$E = 0.4865 - 0.00003981t$; $E_{298.1} = 0.4765$ (plated Ag and AgCl) (193). $E = 0.4765 - 0.000004t$; $E_{298.1} = 0.47638$ (1429)

Tl (in het. amalg.) + $AgCl(s) = Ag(s) + TlCl(s)$

$E_{298.1} = 0.7766$; $dE/dt = -0.0000794$/deg. (470)

Cd (in het. amalg.) + $2AgCl(s) + 2\frac{1}{2}H_2O$ (in satd. $CdCl_2.2\frac{1}{2}H_2O$) = $2Ag(s) + CdCl_2.2\frac{1}{2}H_2O(s)$; $E = 0.6249 - 0.000004t$; $E_{298.1} = 0.62478$ (1429)

Cd (amalg., $x_2 = 0.0792$) + $2AgCl(s) + 2\frac{1}{2}H_2O$ (in satd. $CdCl_2.2\frac{1}{2}H_2O$) = $2Ag(s) + CdCl_2.2\frac{1}{2}H_2O(s)$; $E_{298.1} = 0.62203$ (648)

$Hg(l) + AgCl(s) = Ag(s) + HgCl(s)$

$E^0 = A + Bt$

A	B	$E^0_{298.1}$	Remarks	Lit.
0.0385	0.00035	0.0473	Plated Ag and AgCl	(187)
0.0365	0.000362	0.0455		(196)
0.03705	0.000338	0.0455	In KCl, in *m* HCl	(470)
		0.0455	In HCl and KCl	(1195)
0.0362	0.000336	0.0446		(1548)

$CuCl(s) + AgCl(s) = Ag(s) + Cu^{++} + 2Cl^-$ (367)

$m_{(Cu^{++})}$	$m_{(CuCl_2)}$	$m_{(Cl^-)}$	$m_{(Cu^+)}$	μ
		$T = 298.1°K$		
0.00976	0.00160	0.02402	0.00015	0.0354
.00813	.00178	.02694	.00007	.0368
.00411	.00265	.0399		.0466
.00134	.00558	.08405		.0910
.00057	.01145	.1743		.1863
.00048	.01503	.2224		.2375
.00038	.01800	.2733		.2920
		$T = 313.1°K$		
0.01042	0.00236	0.02168	0.00059	0.0345
.00814	.00264	.02422	.00050	.0350
.00571	.00334	.03071	.00056	.0398
.00317	.00466	.04277	.00034	.0506
.00200	.00634	.05813	.00027	.0665
.00124	.00890	.0826		.0927
.00100	.01093	.0987		.1106
.000832	.0173	.1675		.1852

$AgCl(s) = Ag^+ + Cl^- + (?)$ complex

In HCl(aq) at 298.1°K (432, 433)

$c_{(HCl)}$	$c_{(\Sigma Ag \times 10)}$	$c_{(HCl)}$	$c_{(\Sigma Ag \times 10^3)}$
0.00478	0.00075	0.9258	0.0719
.00938	.00084	1.300	.126
.0178	.00125	1.911	.266
.0341	.00219	2.149	.374
.0741	.00361	2.569	.610
.0914	.00426	2.975	.814
.3167	.01403	3.576	1.358
.649	.032	4.182	2.147
.6818	.0448	4.735	3.168
.7797	.0559	5.508	5.126

AgCl(s).—(*Continued*)

In HNO_3(aq) at 298.1°K (498)

$c_{(HNO_3)}$	$c_{(\Sigma Ag \times 10^3)}$	$c_{(HNO_3)}$	$c_{(\Sigma Ag \times 10)^3}$
0.0005	1.15	0.3	1.57
.001	1.19	1.5	1.71
.01	1.24		

In NH_4Cl(aq) at 298.1°K (432, 498); *cf.* (433, 1316)

$c_{(NH_4Cl)}$	$c_{(\Sigma Ag \times 10^3)}$	$c_{(NH_4Cl)}$	$c_{(\Sigma Ag \times 10^3)}$
0.00001	0.0112 (498)	2.918	2.160
.0001	.0166 (498)	3.162	2.795
.513	.042	3.510	4.029
.926	.113	4.363	9.353
1.141	.172	4.902	14.92
1.574	.365	5.503	24.04
2.143	.842	5.764	30.17
2.566	1.425		

In NH_4NO_3(aq), $c = 0.01$ (1261)

T, °K	$c_{(\Sigma Ag)}$	T, °K	$c_{(\Sigma Ag)}$
291.1	1.04×10^{-5}	298.1	1.43×10^{-5}

In $Hg(NO_3)_2$(aq) at 298.1°K (1019)

$c_{(Hg(NO_3)_2)}$	$c_{(\Sigma Ag)}$	$c_{(Hg(NO_3)_2)}$	$c_{(\Sigma Ag)}$
0.01	0.00432	0.05	0.00914
.0125	.00499	.1	.01395
.025	.00690	1.0	.04810

In $AgNO_3$(aq) at room temperature (432); *cf.* (917)

$c_{(AgNO_3)}$	$c_{(\Sigma Cl \times 10^3)}$
2.0	0.03

In $ZnCl_2$(aq) at 298.1°K (432)

$c_{(ZnCl_2)}$	$c_{(\Sigma Ag \times 10^3)}$
1.694	0.364

In $CaCl_2$(aq) at 298.1°K (432); *cf.* (433)

$c_{(CaCl_2)}$	$c_{(\Sigma Ag \times 10^3)}$	$c_{(CaCl_2)}$	$c_{(\Sigma Ag \times 10^3)}$
0.874	0.289	1.868	2.182
1.100	.501	2.016	2.802
1.370	.900	2.269	4.175
1.632	1.463	2.503	5.823

In $SrCl_2$(aq) at 298.1°K (432); *cf.* (433)

$c_{(SrCl_2)}$	$c_{(\Sigma Ag \times 10^5)}$	$c_{(SrCl_2)}$	$c_{(\Sigma Ag \times 10^3)}$
0.275	0.033	1.238	0.747
.494	.092	1.496	1.252
.679	.173	1.747	2.018
.786	.236	1.797	3.594
.849	.284	4.087	8.174
.909	.348	6.02	12.04
1.070	.510		

In $BaCl_2$(aq) at 298.1°K (432)

$c_{(BaCl_2)}$	$c_{(\Sigma Ag \times 10^3)}$	$c_{(BaCl_2)}$	$c_{(\Sigma Ag \times 10^3)}$
0.624	0.186	1.338	1.274
.805	.339	1.630	2.366

In NaCl(aq) at 298.1°K (432, 433); *cf.* (917)

$c_{(NaCl)}$	$c_{(\Sigma Ag \times 10)}$	$c_{(NaCl)}$	$c_{(\Sigma Ag \times 10^3)}$
0.00386	0.00072	0.9747	0.0806
.00924	.00091	1.190	.130
.01758	.00131	1.433	.184
.03654	.00189	1.617	.245
.08844	.00361	1.871	.348
.3556	.0174	2.094	.446
.5112	.0280	2.272	.570
.933	.086	2.449	.684

AgCl(s).—(*Continued*)

c(NaCl)	$c(\Sigma\text{Ag} \times 10^3)$	c(NaCl)	$c(\Sigma\text{Ag} \times 10^3)$
2.658	0.851	3.977	2.879
2.841	1.040	4.170	3.335
3.000	1.194	4.363	3.810
3.270	1.583	4.535	4.298
3.471	1.897	5.039	6.039
3.747	2.462		

In NaCl + $NaNO_3$(aq) at 298.1°K (432)

c(NaCl)	$c(NaNO_3)$	$c(\Sigma\text{Ag} \times 10^3)$
3.743	0.00	2.457
3.592	.84	2.493
3.462	1.50	2.538

In KCl (aq) (432)

c(KCl)	$c(\Sigma\text{Ag} \times 10^3)$	c(KCl)	$c(\Sigma\text{Ag} \times 10^3)$
T = 274.1°K		T = 298.1°K.—(*Cont'd*)	
3.325	1.734	2.850	1.845
T = 298.1°K		3.081	2.435
1.111	0.141	3.083	2.415
1.425	.235	3.424	3.602
1.713	.391	3.843	5.725
2.022	.616	T = 308.1°K	
2.396	1.050	2.955	2.786
2.628	1.390		

T = 298.1°K (498)

$c(\text{KCl} \times 10^5)$	$c(\Sigma\text{Ag} \times 10^5)$	$c(\text{KCl} \times 10^5)$	$c(\Sigma\text{Ag} \times 10)$
3.16	1.28	20.0	2.13
6.32	1.52	40.0	2.24

In KNO_3(aq) (1261)

T	c(KCl)	$c(\Sigma\text{Ag} \times 10^5)$
291.1	0.01	1.04
298.1	.01	1.43

AgCl(s) = AgCl(l)

$\Delta H^0 = 3\ 050$; $\Delta F^0_{724.1} = 0$ (506); $\Delta F^0_{298.1} = 1\ 900$ (161)

$AgCl.NH_3(s) = AgCl(s) + NH_3(g)$ (107) (E)

T	P	T	P
273.1	0.022	315.1	0.316
289.4	0.055	316.1	0.332
304.1	0.132*	332.1	0.807
305.9	0.155	336.1	0.859
	ΔH = 11 110 (94)		

* Interpolated.

$AgCl.1\frac{1}{2}NH_3(s)$ = (mixed crystals of lower NH_3 content) + $xNH_3(g)$ (94, 107) (E)

T	P	T	P
273.1	0.0553	292.1	0.209
278.1	0.0724	299.1	0.304
287.1	0.132*	305.9	0.482
289.6	0.153	ΔH = 10 520x	

* Interpolated from (94); all other values from (107). For NH_3 content of somewhat less than 1½ molecules, the pressure-temperature curves show irregularities (decrease of pressure with rise of temperature), on account of mixed crystals of a composition depending upon the temperature (107); *cf.* (650, 666, 696).

$2AgCl.3NH_3(s) + 3H_2O(l) = 2AgCl(s) + 3NH_4OH(aq)$ (1410)

T = 298.1°K

$m(\Sigma NH_3)$	$m(\Sigma\text{Ag})$	$m(NH_4OH)$	$K^{1/3}$	μ
6.26	0.745	4.77	4.77	0.745
6.27	.754	4.76	4.76	.754
6.25	.757	4.74	4.74	.757
6.25	.760	4.73	4.73	.760

$AgCl.3NH_3(s) = AgCl.1\frac{1}{2}NH_3(s) + 1\frac{1}{2}NH_3(g)$ (94, 107, 384); *cf.* (646, 650, 696) (E)

T	P	T	P
248.1	0.0743	282.1*	0.611
253.1*	0.0842	282.6	0.612
257.1	0.111	287.1	0.832
260.1†	0.132†	289.1*	0.875
273.1	0.357	289.4	0.922
273.1*	0.338	290.4*	0.968
	ΔH = 13 740		

* From (384). † Interpolated from (94); all other values from (107).

$AgCl.CH_3NH_2(s) = AgCl(s) + CH_3NH_2(g)$ (696) (E)

T	P	T	P
273.1	0.012	314.1	0.221
282.6	0.025	319.6	0.309
288.1	0.037	324.1	0.411
289.9	0.042	334.1	0.770
293.6	0.057	338.1	0.993
305.1	0.121		

$AgClO_3.3NH_3(s)$ = (?) + $xNH_3(g)$ (384) (E)

T	P	T	P
284.1	0.012	288.6	0.559
319.1	0.428	338.6	1.000 (extrap.)

$AgClO_4.3NH_3(s)$ = (?) + $xNH_3(g)$ (384) (E)

T	P	T	P
282.1	0.042	350.1	0.896
315.1	0.209	351.4	0.945
332.6	0.442	352.1	0.961
344.1	0.704		

AgBr(s)

$E^0_{298.1} = 0.9925$; $\Delta F^0_{298.1} = -22\ 910$ (1189) *from* (890); *cf.* (1181)

$\frac{1}{2}H_2(g) + AgBr(s) = Ag(s) + H^+ + Br^-$ (890)

Constant = −0.6103; $E^0_{298.1} = 0.0725$; $\Delta F^0_{298.1} = -1\ 673$

$m^{1/2}$	$E_{298.1}$	log γ + const.
0.1	0.3141	−0.6551
.1732	.2604	−0.6783
.3162	.2022	−0.7092

$Pb(s) + 2AgBr(s) = 2Ag(s) + PbBr_2(s)$

$E^0 = 0.3552 - 0.000126t$; $E^0_{298.1} = 0.3520$ (amorphous AgBr);
$E^0 = 0.3550 - 0.000123t$; $E^0_{298.1} = 0.3517$ (fused AgBr) (792);
$E^0 = 0.3592 - 0.000275t$; $E^0_{298.1} = 0.3524$ (1173)

Pb (in het. amalg.) + $2AgBr(s) = 2Ag(s) + PbBr_2(s)$

$E = 0.3537 - 0.000289t$; $E_{298.1} = 0.3465$ (1173)

$AgBr(s) = Ag^+ + Br^-$ + (?) complex

In $Hg(NO_3)_2$ (aq) at 298.1°K (1019)

$c(Hg(NO_3)_2)$*	$c(\Sigma\text{Ag})$	$c(Hg(NO_3)_2)$*	$c(\Sigma\text{Ag})$
0.0100	0.00306	0.05	0.00639
.0125	.00329	.1	.00873
.025	.00459	1.0	.03660

* HNO_3 present in these solutions.

In KBr (aq) at 298.1°K (597)

c(KBr)	$c(\Sigma\text{Ag})$	c(KBr)	$c(\Sigma\text{Ag})$
2.76	0.0117	4.44	0.0955
3.68	.0400	4.864	.1407
4.18	.0718		

$AgCl(s) + Br^- = AgBr(s) + Cl^-$

$E^0_{298.1} = 0.150$; $\Delta F^0_{298.1} = -3\ 461$ (1181) *from* (505)

AgBr.NH$_3$(s) = AgBr(s) + NH$_3$(g) (107, 707) (E)

ΔH =: 10 650 (94); $\log P = -4\ 033/T - 13.249 \log T + 44.7039$

T	P	T	P
273.1	0.039	310.6	0.479
278.1	0.067	316.1	0.726
305.6	0.367	324.6*	1.000

* From (707); all other values from (107).

AgBr.1½NH$_3$(s) = (Unsaturated mixed crystals with AgBr.NH$_3$) + xNH$_3$(g) (696, 707) (E)

T	P	T	P
273.1	0.116	289.7	0.328
277.1	0.141	301.7	0.675
283.5	0.218	307.1*	1.000
284.3	0.229	316.9	1.612
287.1	0.271	326.1	2.613

* From (707); all other values from (696).

$\Delta H = 9\ 950x$ (94); $\log P = -6650.6/T - 34.239 \log T + 108.3096$ (707); according to (107), the decomposition of the mixed crystals gives:

Moles NH$_3$	T	P
1.32	278.1	0.149
1.22	305.6	0.538
1.23	315.7	0.921

AgBr.3NH$_3$(s) = AgBr.1½NH$_3$(s) + 1½NH$_3$(g) (E)

$P_{276.6} = 1.00$; $\log P = -1787.13/T + 1.075 \log T + 2.8340$ (707); $\Delta H = 12\ 960$ (94); *cf.* (696)

AgBr.CH$_3$NH$_2$(s) = AgBr(s) + CH$_3$NH$_2$(g) (696) (E)

T	P	T	P
273.1	0.014	318.3	0.382
292.6	0.068	328.1	0.676
93.6	0.076		

AgBrO$_3$(s) = Ag$^+$ + BrO$_3^-$ (626)

$\Delta F^0_{298.1} = 5847$; $K = 5.20 \times 10^{-5}$

AgBrO$_3$.3NH$_3$(s) = (?) + xNH$_3$(g) (384) (E)

T	P	T	P
252.1	0.276	274.1	1.000
267.1	0.662	274.6	1.053
273.1	0.947		

AgI(l) = Ag(s) + ½I$_2$(g) (1045)

AgI(s)

$E^0_{298.1} = 0.6856$; $\Delta F^0_{298.1} = -15\ 820$ in 0.1N KI (470); *cf.* (730, 731, 1119)

Ag(s) + ½I$_2$(s) = AgI(s)

$E^0 = \mathrm{A} + \mathrm{B}t$

A	B	$E^0_{298.1}$	Remarks	Lit.
		0.6831	0.5N KI	(424)
		0.6812	0.333N KI	(424)
0.6818	0.000152	0.6856	0.1N KI	(470)
($E^0_{273.1}$ = 0.6834)		0.6872	1N KI	(470)
		0.6842	0.5N KI	(476)
		0.6821	0.025N KI	(476)
($E^0_{273.1}$ = 0.6812)		0.6858	0.1N	(729, 1189)
($E^0_{273.1}$ = 0.6798)		0.6850	0.05N	(729, 1189)
0.6823	0.000160	0.6863	0.1N	(729, 730)
0.67974	0.000217	0.68516	0.05N	(730)
0.67961	0.000206	0.68475	0.02N	(730)
0.67927	0.000209	0.68462	0.01N	(730)
0.68253	0.000084	0.68463	0.33N (*ca.*)	(730)
		0.6857		(1119)

Pb(s) + 2AgI(s) = 2Ag(s) + PbI$_2$(s)

$E^0 = \mathrm{A} - \mathrm{B}t$

A	B	$E^0_{298.1}$	Remarks	Lit.
0.2183	0.000177	0.2139	0.1N KI (AgI, amorph.)	(470)
0.2167	0.000178	0.2123	1N KI (AgI, amorph.)	(470)
0.2146	0.000130	0.2114	AgI, amorph.	(792)
0.2145	0.000137	0.2111	AgI, fused	(792)

Pb (in het. amalg.) + 2AgI(s) = 2Ag(s) + PbI$_2$(s)

$E = 0.2128 - 0.000191t$; $E_{298.1} = 0.2080$, 0.1N KI; $E = 0.2112 - 0.000192t$; $E_{298.1} = 0.2064$, N KI (470)

Pb (amalg., $x_2 = 0.00697$) + 2AgI(s) = PbI$_2$ + 2Ag(s)

$E_{273.1}$	$E_{298.1}$	Remarks	Lit.
0.20965	0.20065	0.05N KI	(1426)
0.20905	0.19977	0.1N KI	(1426)
0.20405	0.19625		(1429)

Cd (in het. amalg.) + 2AgI(s) = 2Ag(s) + CdI$_2$(s)

$E_{273.1} = 0.3006$; $E_{298.1} = 0.3035$; $E_{313.1} = 0.3050$ (1429)

AgI(s) = Ag$^+$ + I$^-$ + (?) complex

In Hg(NO$_3$)$_2$(aq) at 298.1°K (1019)

$c_{(\mathrm{Hg(NO_3)_2})}$*	$c_{(\Sigma\mathrm{Ag})}$	$c_{(\mathrm{Hg(NO_3)_2})}$*	$c_{(\Sigma\mathrm{Ag})}$
0.0100	0.00340	0.050	0.00740
.0125	.00358	.10	.01161
.025	.00476	1.0	.10700

* Solutions contain HNO$_3$.

In AgNO$_3$(aq) at 298.1°K (597)

$c_{(\mathrm{AgNO_3})}$	$c_{(\Sigma\mathrm{I})}$	$c_{(\mathrm{AgNO_3})}$	$c_{(\Sigma\mathrm{I})}$
0.20	0.000289	0.50	0.00127
.35	.000532	.75*	.00362

* In more concentrated solutions there is a complex solid phase.

AgI(s) = AgI (hexag.)

$\Delta F^0_{298.1} = -531$ (1181)

AgI.½NH$_3$(s) = (?) + xNH$_3$(g) (696, 707) (E)

$\log P = -3438.36/T - 8.88031 \log T + 31.1991$ (707)

T	P	T	P
273.1	0.004	338.1	0.355
292.1	0.016	353.1	0.638
310.1	0.068	363.1*	1.000
312.1	0.083	373.1	1.506
325.6	0.204	$\Delta H = 11\ 590x$ (94)	

* From (707); all other values from (696).

AgI.NH$_3$(s) = (?) + xNH$_3$(g) (94, 107, 696, 707) (E)

$\log P = -1787.1294/T + 1.0741 \log T + 2.8340$ (707)

T	P	T	P
241.1*	0.0789	276.6‡	0.921
246.1†	0.132	279.3	1.079
250.1	0.191	283.6	1.388
260.1	0.368	288.1	1.816
273.1	0.770	293.6	2.658
273.1‡	0.812	$\Delta H = 8\ 650x$†	

* From (107). † From (94). ‡ From (707); all other values from (696).

AgI.1½NH$_3$(s) = (?) + xNH$_3$(g) (94, 107) (E)

T	P	T	P
215.8	0.102	241.5	0.475
223.1*	0.132	253.1	0.912
231.6	0.204	$\Delta H = 7\ 250x$*	

* From (94); value at 223.1°K interpolated; all other values from (107).

AgI.2NH$_3$(s) = (?) + xNH$_3$(g) (94, 107) (E)

T	P	T	P
194.1	0.022	216.1*	0.132 (extrap.)
215.8	0.136	$\Delta H = 7\ 050$*	

* From (94); all other values from (107).

$AgI.3NH_3(s) = (?) + xNH_3(g)$ (94, 107) (E)

T	P	T	P
194.1	0.042	231.6	0.467
212.1*	0.132	241.5	0.833
215.8	0.162	$\Delta H = 6\ 920x$*	

* From (94); value at 212.1°K extrapolated; all other values from (107).

$AgI.mNH_3(s) = (?)$ (E)

The decomposition of all compounds results in formation of mixed crystals (107)

$AgI.CH_3NH_2(s) = (?) + xCH_3NH_2(g)$ (696) (E)

T	P	T	P
273.1	0.046	313.1	1.056
288.1	0.187	318.1	1.487
298.6	0.395	320.1	1.592
302.6	0.530	324.1	1.789
307.1	0.724	329.1	2.072
311.1	0.938	333.1	2.296

$AgIO_3(s) = Ag^+ + IO_3^-$

$K_{298.1} = 5.29 \times 10^{-8}$; $\Delta F^0_{298.1} = 10\ 270$ (1084)

$5AgIO_3(s) + 3I_2(aq) + 3H_2O(l) = 5AgI(s) + 6H^+ + 6IO_3^-$

$\Delta F^0_{298.1} = 4\ 190$ (885) *from* (1291)

$Ag(SO_3)_2^{---}$; $\Delta F^0_{298.1} = -226\ 545$ (1181)

$AgCl(s) + 2SO_3^{--} = Ag(SO_3)_2^{---} + Cl^-$ (1181) *from* (924, 1463); *cf.* (1465)

$K_{298.1} = 0.0578$; $\Delta F^0_{298.1} = 1\ 690$

Total $c_{(SO_3)}$	$c_{(AgCl)}$	$c_{(SO_3^{--},\ free)}$	$\log K_c + 2$	$\mu_c^{1/2}$
0.937	0.142	0.653	0.672	1.72
.890	.140	.610	.724	1.68
.652	.103	.446	.633	1.44
.470	.070	.330	.653	1.22
.470	.070	.330	.653	1.22
.472	.070	.332	.653	1.22
.234	.036	.162	.763	0.859
.220	.033	.154	.672	.832
.219	.034	.151	.708	831
.106	.017	.066	.756	579
.080	.011	.058	.591	.501
.079	.012	.055	.602	.499
.478	.057	.364	.663	1.24
.483	.059	.365	.681	1.26

$AgBr(s) + 2SO_3^{--} = Ag(SO_3)_2^{---} + Br^-$ (1181) *from* (924); *cf.* (978, 1465)

$K_{298.1} = 1.76 \times 10^{-4}$; $\Delta F^0_{298.1} = 5\ 124$

Total $c_{(SO_3)}$	$c_{(AgBr)}$	$c_{(SO_3^{--},\ free)}$	$\log K_c + 4$	$\mu_c^{1/2}$
0.675	0.0084	0.658	0.204	1.426
.474	.0055	.463	.146	1.19
.466	.0053	.453	.146	1.18
.232	.0025	.227	.079	0.831
.406*	.0023	.401	.230	1.11
.448*	.0023	.443	.146	1.16

* These solutions contain 0.01*N* sodium bromide.

$Ag(S_2O_3)_2^{---} = Ag^+ + 2S_2O_3^{--}$; $K = 4.20 \times 10^{-14}$ (1118)

$AgBr(s) + 2S_2O_3^{--} = Ag(S_2O_3)_2^{---} + Br^-$ (289, 1219)

$AgI(s) + 2S_2O_3^{--} = Ag(S_2O_3)_2^{---} + I^-$ (289, 1465)

$AgNO_2(s)$

$\Delta F^0_{298.1} = 4\ 900$ (885)

$AgNO_2(s) = Ag^+ + NO_2^-$

$\Delta F^0_{298.1} = 5\ 050$ (885); $K_{298.1} = 2.0 \times 10^{-4}$ (6) *from* (5, 892, 1049, 1050)

$2AgNO_2(s) = Ag^+ + NO_3^- + Ag(s) + NO(g)$

$\Delta F^0_{298.1} = 3\ 600$ (885) *from* (6); $P_{(NO)} = 4.28$ atm.; $m_{(AgNO_3)} = 0.179$ at 328.1°K (885) *from* (6). $P_{(NO)} = 8.35$ atm.; $m_{(AgNO_3)} = 1.10$ at 373.1°K (860). $\Delta F^0_{298.1} = 2\ 680 \pm 200$ (1193, 1194)

$2AgNO_2(s) + I_2$ (in CCl_4) $= 2AgI(s) + N_2O_4$ (in CCl_4) (2)

T	$c_{(I_2)}$*	$c_{(N_2O_4)}$
298.1	0.0397	3.96

* I_2 is 0.35 saturated.

$AgNO_2.3NH_3(s) = (?) + xNH_3(g)$ (383) (E)

T	P	T	P
253.1	0.018	319.1	0.388
273.1	0.041	330.1	0.603
291.1	0.102	338.6	0.855
309.1	0.251	341.1	0.942

$AgNO_3.2NH_3(s) = AgNO_3.NH_3(s) + NH_3(g)$ (E)

$P_{443.1} = 1.0$; the dissociation curves proceed irregularly (707)

$AgNO_3.3NH_3(s) = AgNO_3.2NH_3(s) + (?)\ NH_3(g)$ (383) (E)

$\log P = -5\ 864.68/T - 26.1384 \log T + 82.4857$ (707)

T	P	T	P
273.1	0.037	313.6	0.374
283.1	0.071	323.6	0.595
293.1	0.132	331.6	0.845
304.1	0.236	336.1	1.016

$Ag(NH_3)_2^+$; $\Delta F^0_{298.1} = -4\ 003$ (1181)

$AgCl(s) + 2NH_4OH(aq) = Ag(NH_3)_2^+ + Cl^- + 2H_2O(l)$ (141, 1410, 1523, 1181)

$K_{298.1} = 2.86 \times 10^{-3}$; $\log p.f._{298.1} = 1.272$; $\Delta F^0_{298.1} = 3472$ (1181)

Total $m_{(NH_3)}$	$m_{(Ag^+)}$	$m_{(NH_4OH,\ free)}$	$m_{(NaCl)}$	$\log (1/K'^{1/2}_m)$	$\mu^{1/2}$	Lit.
0.0942	0.004592	0.0838		1.261	0.0764	(141)
.1006	.005164	.0890		1.236	.0804	(141)
.1033	.005343	.0912		1.232	.0820	(141)
.1089	.005665	.0960		1.229	.0835	(1181)
.2084	.01137	.1837		1.208	.1156	(141)
.2947	.01588	.2605		1.215	.1355	(141)
.437	.023	.388		1.227	.161	(1410)
.428	.025	.375		1.176	.167	(1410)
.4881	.02588	.4333		1.204	.169	(141)
.7522	.04758	.6532		1.138	.227	(141)
.7517	.04173	.6440	0.0102*	1.141	.236	(141)
.7477	.04392	.6561	.0102	1.129	.241	(141)
.7503	.03503	.6255	.0256*	1.133	.253	(141)
.9662	.06117	.8394		1.138	.256	(141)
.7458	.03869	.6641	.0255	1.125	.261	(141)
.7550	.02751	.5933	.0513*	1.106	.282	(141)
.7497	.03330	.6788	.0511	1.108	.297	(141)
1.3039	.0895	1.1198		1.097	.307	(1181)
1.700	.1197	1.4545		1.085	.355	(1410)
1.710	.1256	1.4525		1.063	.363	(1181)
1.688	.1308	1.419		1.035	.370	(1410)
1.9044	.13616	1.6252		1.077	.378	(141)
1.8782	.1379	1.5956		1.064	.380	(1181)
2.1339	.1628	1.8009		1.054	.413	(1181)
2.6400	.2151	2.2014		1.010	.473	(1181)
2.8393	.2254	2.3796		1.024	.484	(141)
2.9091	.2395	2.4211		1.005	.498	(1181)
3.7574	.3438	3.0596		0.949	.595	(141)
3.782	.372	3.028		.911	.618	(1410)
3.945	.378	3.171		.924	.624	(1410)
4.6918	.4680	3.7443		.903	.693	(141)
5.10	.574	3.938		.836	.760	(1410)
5.33	.609	4.098		.828	.788	(1410)
5.545	.633	4.265		.829	.803	(1410)

* Added salt, $AgNO_3$.

$AgCl(s) + 2NH_4OH(aq)$.—(*Continued*)

(1523); *cf.* (464, 696, 906, 1148, 1465)

Total $c_{(NH_3)}$	$c_{(AgCl)}$	$c_{(NH_4OH)}$	log $(1/K_c'^{1/2})$	$\mu^{1/2}$
0.0282	0.00141	0.02481	1.245	0.0445
.0285	.00142	.02509	1.247	.0446
.0287	.00143	.02527	1.247	.0447
.0288	.00149	.02525	1.229	.0454
.0585	.00300	.0514	1.224	.0638
.0589	.00297	.0519	1.225	.0636
.0590	.00304	.0518	1.231	.0641
.118	.00625	.1040	1.221	.0881
.118	.00619	.1041	1.226	.0878
.118	.00621	.1041	1.224	.0879
.252	.0139	.2218	1.203	.1271
.252	.0140	.2218	1.200	.1275
.253	.0140	.223	1.202	.1275
.397	.0227	.349	1.191	.1582
.411	.0235	.361	1.186	.163
.416	.0240	.365	1.182	.164
.428	.0249	.375	1.178	.167
.818	.0514	.711	1.141	.236
.863	.0541	.751	1.142	.242
.873	.0555	.758	1.135	.245
.896	.0569	.777	1.135	.248
.903	.0572	.784	1.137	.249
.909	.0584	.788	1.130	.251
.916	.0583	.794	1.134	.251
.961	.0616	.833	1.131	.258
1.991	.147	1.690	1.061	.392
2.013	.149	1.708	1.060	.395
2.017	.149	1.712	1.061	.395
2.042	.151	1.733	1.060	.398

$AgBr(s) + 2NH_4OH(aq) = Ag(NH_3)_2^+ + Br^- + H_2O(l)$ (1181)

from (141, 1523)

Total $c_{(NH_3)}$ (1523)	$c_{(AgBr)}$	$c_{(NH_4OH,\ free)}$	log $(1/K_c^{1/2})$	$\mu_c^{1/2}$
0.0777	0.000264	0.0760	2.469	0.0384
.0764	.000276	.0747	2.433	.0384
.118	.000386	.1115	2.476	.0436
.115	.000391	.1125	2.459	.0435
.273	.001070	.269	2.400	.0586
.268	.000941	.264	2.448	.0573
.497	.001590	.491	2.490	.0694
.450	.001700	.445	2.418	.0691
Total $m_{(NH_3)}$ (141)	**$m_{(AgBr)}$**	**$m_{(NH_4OH,\ free)}$**	**log $(1/K_m^{1/2})$**	**$\mu^{1/2}$**
0.1932	0.00060	0.1901	2.501	0.0504
.3849	.00120	.3797	2.500	.0630
.5741	.00179	.5682	2.502	.0724
.7573	.00223	.7488	2.526	.0789
1.965	.00692	1.944	2.449	.1166
3.024	.01163	2.992	2.410	.1257
5.244	.02443	5.181	2.326	.1894

log $p.f._{298.1}$ = 2.537; $K_{298.1}$ = 8.4×10^{-4}; $\Delta F^0_{298.1}$ = 6 934; (1181); *cf.* (696, 906, 1148)

$AgI(s) + 2NH_4OH(aq) = Ag(NH_3)_2^+ + I^- + 2H_2O(l)$ (61, 62, 807, 906)

$Ag(NH_3)_2Cl(aq)$ (1181)

m	log γ	(log $\gamma)/\mu^{1/2}$
0.001	−0.017	−0.530
.002	−0.024	−0.535
.005	−0.040	−0.566
.01	−0.056	−0.560
.02	−0.080	−0.566
.05	−0.126	−0.563
.1	−0.176	−0.556
.2	−0.248	−0.554
.5	−0.382	−0.540

$2AgP_2(s) = 2Ag(s) + P_4(g)$ (507)

T	P	T	P
663.1	0.0771	793.1	0.2275
673.1	.0776	878.1	.2816
723.1	.1436	883.1	.2822

$AgHCO_3(s) = Ag^+ + HCO_3^-$

$K_{291.1}$ = 1.23×10^{-4}; $\Delta F^0_{291.1}$ = 5 210 (1191) *from* (564)

$AgCN(s)$; $\Delta F^0_{298.1}$ = 38 499 (1181)

$AgCN.NH_3(s) = AgCN(s) + NH_3(g)$ (E)

$P_{373.1} = 0.091$; $\log P = -12\,497.12/T - 58.7176 \log T + 183.4738$ (707)

$AgCl(s) + CNS^- = AgCNS(s) + Cl^-$ (1181) *from* (624)

$K_{298.1}$ = 161; $\Delta F^0_{298.1}$ = −3 012

$c_{(Cl^-)}$	$c_{(CNS^-)}$	log K_c	$\mu_c^{1/2}$
0.197	0.00104	2.278	0.450
.193	.00100	2.286	.450
.0501	.00293	2.232	.224
.0489	.00280	2.242	.224
.010	.00060	2.222	.10
.010	.00057	2.244	.10

$AgBr(s) + CNS^- = AgCNS(s) + Br^-$ (1181) *from* (624)

$K_{298.1}$ = 0.505; $\Delta F^0_{298.1}$ = 404

$c_{(Br^-)}$	$c_{(CNS^-)}$	log K_c	$\mu_c^{1/2}$
0.0647	0.1205	0.270	0.447
.0665	.1207	.258	.447
.0165	.0312	.276	.224
.0176	.0324	.265	.224

$AgC_2H_3O_2(s)$ (Acetate) $+ H^+ = Ag^+ + C_2H_4O_2^-$

In $HNO_3(aq)$ at 298.1°K (629, 630)

$c_{(\Sigma H^+)}$	$c_{(Ag^+)}$	d^{25}_{25}
0.0	0.0667	1.005
.4845	.511	1.072
.9506	.970	1.140
1.789	1.841	1.267
3.269	3.290	1.470
3.923	3.929	1.561
4.703	4.745	1.670

$Ag(CN)_2^-$; $\Delta F^0_{298.1}$ = 72 047 (1181)

$AgCl(s) + 2CN^- = Ag(CN)_2^- + Cl^-$ (1465); *cf.* (1143, 1144, 1145)

T = 298.1°K

$m_{(Cl^-)}$	$m_{(Ag(CN)_2^-)}$	$m_{(CN^-)}$	K
0.192	0.192	0.384	0.25

$AgCl(s) + 2HCN(aq) = 2H^+ + Ag(CN)_2^- + Cl^-$ (1181)
$K_{298.1} = 1.9 \times 10^{-9}$; $\log p.f._{298.1} = 2.180$; $\Delta F^0_{298.1} = 11\ 902$

$m_{(HCN(aq))}$	$m_{(acid)}$	$m_{(complex)}$	$m_{(chloride)}$	log $(1/K_m^{1/4})$	$\mu^{1/2}$
0.0938	0.00303	0.00132	0.00161	2.163	0.0552
.1831	.00430	.00182	.00258	2.146	.0652
.2292	.00493	.00199	.00294	2.141	.0702

$AgBr(s) + 2CN^- = Ag(CN)_2^- + Br^-$ (1465); *cf.* (289, 1143, 1144, 1145)
$T = 298.1$°K

$m_{(Br^-)}$	$m_{(Ag(CN)_2^-)}$	$m_{(CN^-)}$	K
0.349	0.349	0.070	24.8

$AgI(s) + 2CN^- = Ag(CN)_2^- + I^-$ (1181)
$K_{298.1} = 221$; $\Delta F^0_{298.1} = -3\ 201$

Total $m_{(CN^-)}$	$m_{(AgI)}$	$m_{(CN^-,\ free)}$	$m_{(NaOH,\ added)}$	log $K_m^{1/2}$	$\mu^{1/2}$
0.01837	0.00866	0.00065	0.0197	1.131	0.192
.03676	.01778	.00120	.0200	1.170	.238
.05521	.02666	.00191	.0199	1.146	.275
.07337	.03549	.00239	.0196	1.173	.305

AgI (hexag.) $+ 2CN^- = Ag(CN)_2^- + I^-$ (1181)
$K_{298.1} = 90.4$; $\Delta F^0_{298.1} = -2\ 670$

Total $m_{(CN^-)}$	$m_{(AgI)}$	$m_{(CN^-,\ free)}$	$m_{(NaOH,\ added)}$	log $(K_m^{1/2})$	$\mu^{1/2}$
0.0208	0.0102	0.00049	0.0244	1.301	0.212
.0208	.0093	.0021	.0244	0.653	.212
.0405	.0191	.00224	.0444	.931	.292
.0836	.0386	.00456	.0946	.938	.423
.0836	.0396	.00434	.0946	.961	.423
.146	.0684	.00889	.1738	.886	.566
.195	.0911	.0126	.2433	.858	.663
.195	.0916	.0116	.2433	.897	.663
.261	.1217	.0177	.2448	.836	.712
.318	.1474	.0232	.2421	.802	.748
.318	.1475	.0230	.2421	.806	.748
.398	.1840	.0300	.2424	.788	.800

$AgCN(s) + HCN(aq) = H^+ + Ag(CN)_2^-$ (1181)
$K_{298.1} = 3.77 \times 10^{-5}$; $\log p.f._{298.1} = 2.212$; $\Delta F^0_{298.1} = 6\ 038$

$m_{(HCN(aq))}$	$m_{(HAg(CN)_2)}$	log $(1/K_m^{1/2})$	$\mu^{1/2}$
0.0296	0.000983	2.244	0.0314
.1016	.002039	2.144	.0452
.1596	.00245	2.211	.0496
.1780	.00366	2.067	.0606
.1825	.00246	2.198	.0544
.2124	.00292	2.197	.0541
.2245	.00272	2.241	.0523
.2275	.00424	2.050	.0652
.2325	.00316	2.184	.0562
.3000	.00375	2.164	.0612
.3625	.00331	2.254	.0576
.4230	.00400	2.210	.0653
.4260	.00511	2.106	.0612
.4465	.00427	2.195	.0654

$AgCl(s) + 2CH_3NH_2(aq)$ (methylamine) $= Ag(CH_3NH_2)_2^+ + Cl^-$ (140, 403.5, 1534)

$AgBr(s) + 2CH_3NH_2(aq)$ (methylamine) $= Ag(CH_3NH_2)_2^+ + Br^-$ (140, 696, 1534)

$AgBr(s) + 2CNS^- = Ag(CNS)_2^- + Br^-$ (1181)

Total $m_{(KCNS)}$	$m_{(AgBr)}$	$m_{(KCNS,\ free)}$	log $(K_m^{1/2})$
0.2510	0.0011	0.249	−2.340
.2702	.0012	.267	−2.340
.5205	.0095	.501	−1.722
.5819	.0085	.564	−1.824
.7577	.0285	.701	−1.390
.7762	.0307	.715	−1.367
1.0089	.0663	.875	−1.122
1.0089	.0668	.875	−1.118

$AgI(s) + 2CNS^- = Ag(CNS)_2^- + I^-$ (1181)

Total $m_{(KCNS)}$	$m_{(AgI \times 10^4)}$	$m_{(KCNS,\ free)}$	log $(K_m^{1/2})$
0.202	0.20	0.202	−4.00
.315	.14	.315	−4.30
.425	.67	.425	−3.91
.500	.51	.500	−4.00
.608	.40	.608	−4.18
.710	.97	.710	−3.85
.765	1.46	.765	−3.72
1.009	1.63	1.008	−3.80

$AgCNS(s) + CNS^- = Ag(CNS)_2^-$ (1181)

Original $m_{(KCNS)}$	$m_{(AgCNS)}$	$m_{(KCNS,\ free)}$	log (K_m)
0.312	0.00202	0.310	−2.187
.564	.0121	.512	−1.627
.870	.0458	.824	−1.255
1.124	.0985	1.026	−1.018

$Ag((NH_2)_2CS)_3^+ = Ag^+ + 3(NH_2)_2CS(aq)$ (thiourea)
$K = 1.39 \times 10^{-14}$ at $T = 293°K$ (?) (1118)

$Ag(CH_3CN)_2^+ = Ag^+ + 2CH_3CN(aq)$ (acetonitrile)
$K = 5.93 \times 10^{-2}$ at $T = 293°K$ (?) (1118)

$Ag(CH_2NH_2COO)_2^- = Ag^+ + 2CH_2NH_2COO^-$ (glycine)
$K = 1.10 \times 10^{-5}$ at $T = 293°K$ (?) (1118)

$AgCl(s) + 2C_2H_5NH_2(aq)$ (ethylamine) $= Ag(C_2H_5NH_2)_2^+ + Cl^-$ (140, 403.5, 1534)

$Ag((CH_3)_2NH)_2^+ = Ag^+ + 2(CH_3)_2NH(aq)$ (dimethylamine)
$K = 2.53 \times 10^{-6}$ at $T = 293°K$ (?) (1118)

$AgBr(s) + 2C_2H_5NH_2(aq)$ (ethylamine) $= Ag(C_2H_5NH_2)_2^+ + Br^-$ (140, 1534)

$Ag(C_2H_4(NH_2)_2)_2^+ = Ag^+ + 2C_2H_4(NH_2)_2(aq)$ (ethylenediamine) (708)

$Ag(C_2H_5CN)_2^+ = Ag^+ + 2C_2H_5CN(aq)$ (propionitrile)
$K = 0.114$ at $T = 293°K$ (?) (1118)

$Ag(C_2H_4(CN)_2)_2^+ = Ag^+ + 2C_2H_4(CN)_2(aq)$ (ethylene cyanide)
$K = 0.1$ at $T = 293°K$ (?) (1118)

$Ag((C_2H_5)_2NH)_2^+ = Ag^+ + 2(C_2H_5)_2NH(aq)$ (diethylamine)
$K = 1.71 \times 10^{-6}$ at $T = 293°K$ (?) (1118); *cf.* (709)

$Ag(C_6H_5NH_2)_2^+ = Ag^+ + 2C_6H_5NH_2(aq)$ (aniline)
$K = 5.85 \times 10^{-4}$ at $T = 293°K$ (?) (1118)

$Ag((C_2H_5)_3N)_2^+ = Ag^+ + 2(C_2H_5)_3N(aq)$ (triethylamine)
$K = 8.85 \times 10^{-5}$ at $T = 293°K$ (?) (1118)

$Ag((CH_2)_6N_4)_2^+ = Ag^+ + 2(CH_2)_6N_4(aq)$ (hexamethylenetetramine)
$K = 2.65 \times 10^{-4}$ at $T = 293°K$ (?) (1118); *cf.* (709)

$Ag(C_7H_7NH_2)_2^+ = Ag^+ + 2C_7H_7NH_2(aq)$ (toluidine)
$K = 2.46 \times 10^{-4}$ at $T = 293°K$ (?) (1118)

$AgMnO_4.3NH_3(s) = (?) + xNH_3(g)$ (384) (E)

T	P	T	P
252.1	0.127	283.1	0.882
273.1	0.434	285.1*	0.934
282.1	0.812		

* The substance which has lost no NH_3 has $P = 1$ at 285.1°K.

$2Ag(g) + \frac{1}{2}O_2(g) = Ag_2O(g)$ (1500)

$Ag_2O(s)$; $\Delta F^0_{298.1} = -2\ 395$ (885)

$2Ag(s) + \frac{1}{2}O_2(g) = Ag_2O(s)$ (762, 853, 854)

$\Delta F^0 = -7\ 240 - 1.0T \ln T + 21.95T$; $\Delta H^0_{298.1} = -6\ 942$; $\Delta F^0_{298.1} = -2\ 395$ (885); *cf.* (756, 1428)

T	P	T	P
575.1*	20.5	725.1	213.5
598.1*	32.0	740.8	257.8
647.1	74.3	757.1	323.5
676.1	114.5	773.3	388.3
718.1*	207		

* From (853, 854); all other values from (762).

$Ag_2O(s) + H_2(g) = 2Ag(s) + H_2O(g)$ (491)

$Ag_2O(s) + H_2 = 2Ag(s) + H_2O(l)$

$E^0_{298.1} = 1.582$; $\Delta F^0_{298.1} = -53\ 449$ (218); *cf.* (4, 925)

$Ag_2O(s) + H_2O(l) = 2Ag^+ + 2OH^-$

$\Delta F^0_{298.1} = 10\ 520$ (159); *cf.* (701)

$AgCl(s) + OH^- = \frac{1}{2}Ag_2O(s) + Cl^- + \frac{1}{2}H_2O(l)$ (1084)

$c_{(KOH)}$	$c_{(KCl)}$	μ_c	K_c
$T = 298.1$°K			
0.0542	0.000494	0.0547	0.00902
0.0597	0.000530	0.0602	0.00877
0.0650	0.000620	0.0656	0.00941
0.0707	0.000666	0.0714	0.00928
0.0944	0.000918	0.0953	0.00948
0.1095	0.001046	0.1111	0.00927
0.3297	0.003295	0.3330	0.00999
0.3349	0.003303	0.3382	0.00986
0.3495	0.003410	0.3529	0.00976
0.3568	0.003503	0.3603	0.00982
0.3578	0.003434	0.3612	0.00960
0.3583	0.003540	0.3618	0.00988

In dilute soln., $a_{(H_2O(l))} = 1$(1084); $K_{298.1} = 0.00891$; $\Delta F^0_{298.1} = 2\ 798$ (877, 878, 879, 885)

$2Ag(s) + HgO(s) = Ag_2O(s) + Hg(l)$

$E^0_{298.1} = 0.2312$; $\Delta F^0_{298.1} = -10\ 669$ (218)

$\frac{1}{2}Ag_2O(s) + 2NH_4OH(aq) = Ag(NH_3)_2^+ + OH^- + \frac{3}{2}H_2O(l)$ (1181) *and from* (1523)

log $p.f._{298.1} = 0.247$; log $K_{298.1} = -0.494 \pm 0.005$; $\Delta F^0_{298.1} = 674$ (1181)

m (total base)	$m_{(Ag(NH_3)^+)}$	$m_{(NH_4OH)}$	$1/K^{1/2}_m$	$1/K^{1/2}_{m'}$	log $(1/K^{1/2}_{m'})$	$\mu^{1/2}$
0.05302	0.01155	0.01838	1.59	1.59	0.201	0.107
.05532	.01282	.01667	1.32	1.32	.119	.113
.05821	.01338	.01806	1.35	1.36	.133	.116
.06173	.01406	.01955	1.39	1.40	.146	.119
.1479	.03499	.04289	1.23	1.25	.097	.187
.1575	.03606	.04932	1.37	1.39	.143	.190
.2456	.05787	.07198	1.25	1.26	.100	.240
.3155	.07352	.09490	1.29	1.32	.120	.272
.3200	.07535	.09494	1.26	1.29	.111	.274
.3540	.07787	.1231	1.55	1.59	.201	.279
.6519	.1525	.1945	1.28	1.34	.127	.391
.6767	.1582	.2021	1.28	1.34	.127	.398
.6950	.1623	.2082	1.28	1.35	.130	.403
.8673	.2033	.2574	1.26	1.34	.127	.452
.9518	.2225	.2841	1.26	1.35	.130	.472
1.2304	.2888	.3642	1.26	1.38	.140	.538

$\frac{1}{2}Ag_2O(s) + 2NH_4OH(aq)$.—*(Continued)*

Total $c_{(NH_3)}$	μ_c	$c_{(NH_4OH)}$	$1/K^{1/2}_c$	$(1/K'^{1/2}_c)$	log $(1/K'^{1/2}_c)$	$\mu^{1/2}_c$
0.214	0.0654	0.0832	1.272	1.300	0.114	0.256
.220	.0658	.0884	1.343	1.373	.137	.257
.458	.134	.190	1.417	1.467	.165	.366
.469	.140	.189	1.350	1.412	.150	.374
.671	.205	.261	1.275	1.355	.132	.453
.684	.205	.274	1.337	1.423	.153	.453
.720	.225	.270	1.200	1.288	.110	.474
.733	.224	.285	1.273	1.378	.139	.474
.830	.242	.346	1.430	1.543	.188	.492
.827	.248	.331	1.336	1.446	.159	.498
.811	.251	.309	1.232	1.334	.125	.501
.876	.257	.362	1.408	1.528	.184	.508
.915	.276	.363	1.317	1.435	.156	.526
.899	.278	.343	1.234	1.347	.129	.528
.999	.299	.401	1.340	1.472	.168	.548
1.147	.343	.461	1.344	1.498	.173	.585
1.498	.454	.590	1.298	1.452	.162	.674
1.522	.470	.582	1.238	1.393	.144	.686

$2Ag(s) + H_2S(g) = Ag_2S(s) + H_2(g)$ (1082)

$\Delta F^0_{298.1} = -1\ 688$

T	E(0.1HCl)	E(0.5HCl)	E (mean)
278.1	0.0382	0.0379	0.03805
283.1	.0378	.0376	.0377
298.1	.0367	.0365	.0366
308.1	.0358	.0357	.0357

$2AgI(s) + H_2S(aq) = Ag_2S(s) + 2H^+ + 2I^-$ (1082)

$m_{(H_2S,aq)}$	$m_{(HI)}$	¼ log $(1/K_m)$	$\mu^{1/2}$
0.0002531	0.02435	0.7143	0.1560
.0002954	.02589	.7045	.1609
.0003436	.02664	.7085	.1633
.001006	.03492	.7076	.1869
.002820	.04546	.7050	.2132
.004077	.05047	.6996	.2246
.005053	.05277	.7035	.2297
.006834	.05705	.7025	.2388
.01982	.07491	.6998	.2737
.03318	.08557	.6979	.2925
.03369	.08602	.6973	.2933
.06371	.1015	.6538	3186
.07747	.1068	.6937	.3268
.1116	.1170	.6937	.34205

$Ag_2S(s) = Ag_2S(s')$

$\Delta H^0 = 953$; $\Delta F^0_{298.1} = 239$; $\Delta F^0_{398.1} = 0$ *from* (76); $\Delta F^0_{448.1} = 0$ (452); *cf.* (161, 1323, 1463)

$Ag_2S(s') + H_2(g) = 2Ag(s) + H_2S(g)$ (761)

T	K	T	K
749.15	0.359	889.63	0.278
811.25	.325	$\Delta F^0 = -2\ 408 + 5.253T$	

$Ag_2SO_4(l) = 2Ag(s) + SO_2(g) + (?)$

$P_{1358.1} = 1.00$ (455); *cf.* (636, 949, 950)

$Ag_2CO_3(s) + CO_2(g) + H_2O(l) = 2Ag^+ + 2HCO_3^-$ (1191) *from* (561, 1490); *cf.* (4, 716, 737, 738, 797)

log $p.f._{298.1} = 2.111$; $\Delta H = -16\ 990$; $\Delta F^0_{298.1} = 11\ 525$

T	$m_{(Ag^+)}$	$p_{(CO_2)}$	$f_{(CO_2)}$	$\mu^{1/2}$	log $(1/K_m{}^{1/4})$
291.1*	0.00764	1.0	0.99	0.087	2.1158
298.1	.008338	0.943	.934	.0913	2.0716
298.1	.008353	.943	.934	.0914	2.0711
298.1	.008375	.946	.937	.0915	2.0700

$Ag_2CO_3(s) + CO_2(g) + H_2O(l)$.—*(Continued)*

T	$m_{(Ag^+)}$	$p_{(CO_2)}$	$f_{(CO_2)}$	$\mu^{1/2}$	log $(1/K_m^{1/4})$
298.1	0.008437	0.975	0.966	0.0920	2.0700
291.1*	.01234	56	43.46	.111	2.3182

* From (561); all other values from (1490).

$Ag_2CO_3(s) = Ag_2O(s) + CO_2(g)$ (273, 305); *cf.* (716, 737, 738, 1257)

T	P	T	P
405.1	0.0276	483.1	0.736
440.1	.148	491.1	1.004
455.6	.241	492.1*	1.000

* From (273); all other values from (305).

$3(AgClO_4)_2$ (in C_6H_6, benzene) $= 2(AgClO_4)_3$ (in C_6H_6) (627)

$Ag_2S.AgNO_3(s) = 3Ag^+ + S^{--} + NO_3^-$
In $AgNO_3(aq)$ at 288.1°K* (917)

$m_{(AgNO_3)}$	$m_{(Ag_2S)}$	$m_{(AgNO_3)}$	$m_{(Ag_2S)}$
2.35	0	5.89	0.000916
2.94	tr.	11.8	.00562
3.92	0.000261		

* For data at 373.1°K, *v.* (917).

Au, Gold

$Au(s)$; ΔH^0, $\Delta F^0 = 0$

$Au(OH)_3 = Au^{+++} + 3OH^-$
$K = 5.5 \times 10^{-46}$ (704)

$Au(OH)_3(s) + 3H^+ = Au^{+++} + \frac{3}{2}H_2O(l)$
In $H_2SO_4(aq)$ (703)

T	$c_{(H_2SO_4)}$	$c_{(\Sigma Au)}$
291.1	0.265	0.000016
	.445	.000036
	.505	.000042
	.73	.000081
	.79	.00011
292.1	9.35	.0632

In $HNO_3(aq)$ at 295.1°K (704)

$c_{(HNO_3)}$	$c_{(\Sigma Au)}$
0.45	0.00003

$2AuCl(s) = 2Au(s) + Cl_2(g)$ (989)

T	P	T	P
443.1	0.018	489.1	0.118
460.1	.030	513.1	.289
474.1	.065		

$AuCl.2NH_3(s) = (?) + xNH_3(g)$ (386) (E)

T	P	T	P
381.6	0.789	387.6	1.053
386.6	1.000		

$AuCl_3(s) = AuCl(s) + Cl_2(g)$; *cf.* (1258)

$\log P = -6937/T - 1.177 \log T + 45.823$ (1127); *cf.* (989)

T	P (total)	$P_{(Cl_2(g))}$	Lit.
373.1		0.0076	(1135)
411.6		.0099	
413.1	0.0054		(1127)
423.1	.0092		
433.1	.0131		
443.1	.0237		
453.1	.0403		
454.1		.0678	(1135)
463.1	.0872		(1127)
473.1	.263		
475.1		.1388	(1135)
483.1	.199		(1127)
493.1	.303		
502.1		0.1868	(1135)
503.1	0.438		(1127)
513.1	.629		
523.1	.886		
524.1		1.031	(1135)
526.8	1.000		(1127)
533.1	1.225		

$AuCl_3(s) = AuCl_3(g)$ (1135)

T	P	T	P
454.1	0.0127	599.1 (liquid)	0.0882
524.1	.0324		

$AuCl_3.mNH_3(s) = (?) + xNH_3(g)$ (386) (E)

Equilibrium reversible with difficulty. In decomposition $AuCl_3.12NH_3$ gives $P < 1$ at $T = 255.1$; $AuCl_3.6NH_3$ gives $P < 1$ at room temperature

$2AuBr(s) = 2Au(s) + Br_2(g)$ (989)

T	P	T	P
484.1	0.085	543.1	0.743
503.1	.234		

$AuBr_3(s) = AuBr(s) + Br_2(g)$ (989)

T	P	T	P
438.1	0.085	493.1	0.743
463.1	.234	503.1*	1.000

* Extrapolated.

$AuBr_3.mNH_3(s) = (?) + xNH_3(g)$ (386) (E)

$m = 18$ moles, $P = 1.00$ atm. at $T = 274.1$; $m = 9$ moles, $P = 1.00$ atm. at $T = 284.1$. Between these two compounds there exists a complete series of solid solutions. There are also solid solutions of ammonia content greater than 18 moles, and less than 9 moles. Here increase of NH_3 content causes an increase of pressure, *e.g.*, with 21 moles NH_3, $P = 1.00$ atm. at $T = 258.1$.

$Au(s) + \frac{1}{2}I_2$ (in CCl_4) $= AuI(s)$ (251)

I_2 is 1.088 moles per liter at 298.1°K. (I_2 is 95% saturated; that is, solubility of I_2 is 1.156 moles per liter in CCl_4 at 298.1°)

$AuI(s) = Au^+ + I^-$ (251)
In $KI(aq)$ at 298.1°K

$c_{(KI)}$	$c_{(\Sigma Au)}$	$c_{(I_2)}$*
0.1009	0.0106	0.0482
.2508	.0290	.1308
.4038	.0522	.198
1.0096	.1142	.556

* I_2 = total titratable I_2.

$H_2(g) + Au_2O(s) = 2Au(s) + H_2O(l)$
$E^0_{298.1} = -1.2$ (474) *from* (249, 250)

$Au_2O(s) + 2H^+ = 2Au^+ + H_2O(l)$ (2) *from* (249)
In $HNO_3(aq)$

$c_{(HNO_3)}$	$c_{(\Sigma Au)}$	$c_{(HNO_3)}$	$c_{(\Sigma Au)}$
3.32	0.00002	9.13	0.000041
7.76	.000047	11.66	.000086
8.77	.000053		

$Au_2O_3(s)$
$\Delta F^0_{298.1} = 19\,100$; $\Delta H = -13\,200$; $\Delta S^0_{298.1} = -108.4$ (219)

$3H_2(g) + Au_2O_3(s) = 2Au(s) + 3H_2O(l)$ (219); *cf.* (220, 474, 703, 704, 705)

$m_{(H_2SO_4)}$	$E_{298.1}$	
0.0100	1.3639	
.1000	1.3635	$\Delta F^0_{298.1} = -188\ 800$ $E_{298.1}$ (mean) $=$ 1.364 ± 0.001
1.024	1.3634	

$6Hg(l) + Au_2O_3(s) + 3SO_4^{--} + 6H^+ = 2Au(s) + 3Hg_2SO_4(s) + 3H_2O(l)$ (474)

$m_{(H_2SO_4)}$	$E_{298.1}$	$m_{(H_2SO_4)}$	$E_{298.1}$
0.0506	0.599 ± 0.002	1.031	0.690 ± 0.001
.1031	.629 ± 0.002		

Ir, Iridium

$2IrCl = 2Ir(s) + Cl_2(g)$ (1543, 1544)

T	P	T	P
971.1	0.201	1 046.1	0.599
1 012.1	.337	1 071.1*	1.000
1 024.1	.424	1 072.1	1.014

* Interpolated.

$2IrCl_2 = 2IrCl + Cl_2(g)$ (1543, 1544)

T	P	T	P
984.1	0.317	1 028.1	0.721
1 010.1	.508	1 044.1	.962
1 022.1	.664	1 046.1*	1.000

* Extrapolated.

$2IrCl_3 = 2IrCl_2 + Cl_2(g)$ (1543, 1544)

T	P	T	P
859.1	0.063	1 022.1	0.730
916.1	.116	1 036.1*	1.000
989.1	.395	1 038.1	1.014
1 010.1	.603		

* Interpolated.

Pt, Platinum

$2PtCl = 2Pt(s) + Cl_2(g)$; $P_{855.1} = 1.000$ (1544)

$2PtCl_2 = 2PtCl + Cl_2(g)$; $P_{855.1} = 1.000$ (1544)

$PtCl_2.5NH_3(s)$ = Solid solution + $xNH_3(g)$ (395) (E)

T	P	T	P
277.1	0.395	295.1	1.000
286.1	0.658	$\Delta H = 10\ 300x$	

$2PtCl_3 = 2PtCl_2(g) + Cl_2(g)$; $P_{708.1} = 1.000$ (1544)

$2PtCl_4 = 2PtCl_3 + Cl_2(g)$; $P_{643.1} = 1.000$ (1544)

$PtI_2 = Pt(s) + I_2(g)$ (1045)

T	$P \times 10^5$	T	$P \times 10^5$
416.0	0.6316	437.4	3.408
427.5	1.592		

$PtI_2.4NH_3(s) = (?) + xNH_3(g)$ (395) (E)

T	P	T	P
399.1	0.171	443.6	1.000 (extrap.)
436.1	0.774	$\Delta H = 16\ 100x$	

$PtI_2.6NH_3(s) = PtI_2.4NH_3(s) + 2NH_3(g)$ (395) (E)

T	P	T	P
265.1	0.743	267.6	0.879
266.1	0.770	269.1	1.000 (extrap.)
	$\Delta H = 18\ 600$		

Ru, Ruthenium

$RuO_2(s) = Ru(s)^* + O_2(g)$ (1208); *cf.* (282, 323, 324, 532, 533)

T	P	T	P
1 203	0.026–0.053	1 228	0.066
	$\Delta H = 52\ 200$		

* Ru(s) is slightly soluble in $RuO_2(s)$.

$RuCl_3(s) = Ru(s) + \frac{3}{2}Cl_2(g)$ (1208)

T	P	T	P
962.1	0.154	1 018.1	0.232
993.1	.182	1 039.1	.331
997.1	.186	1 050.1	.387
1 001.1	.200	1 088.1	.693
1 008.1	.225	1 089.1	.739
1 009.1	.211	1 114.1	.957
1 015.1	.246	$H = 94\ 500$	

Pd, Palladium

Pd_2H (in s. satd. Pd) = 2Pd (in s. satd. PdH_2) + $\frac{1}{2}H_2(g)$ (489); *cf.* (639, 644, 813, 1014, 1349, 1461, 1462)

T	P	ΔH
273.1	0.00520	8 780
303.1	.0246	8 700
353.1	.2008	8 450
433.1	1.746	
453.1	2.580	

$PdCl_2.4NH_3(s) = PdCl_2.2NH_3(s) + 2NH_3(g)$ (E)
$P_{483.1} = 1.00$; $\Delta H = 31\ 120$ (669)

$PdI_2.4NH_3(s) = PdI_2.2NH_3(s) + 2NH_3(g)$ (E)
$P_{383.1} = 1.00$; $\Delta H = 25\ 760$ (669)

Mn, Manganese

$Mn^{++} = Mn^{+++} + E^-$; $E^0_{285.1} = -1.511$ (521); *cf.* (523)

$Mn^{+++} = Mn^{++++} + E^-$; $E^0_{285.1} = -1.642$ (521)

$Mn^{++} = Mn^{++++} + 2E^-$; $E^0_{285.1} = -1.577$ (521)

$MnO_2(s) + 2H_2O(l) = MnO_4^- + 4H^+ + 3E^-$
$E^0_{298.1} = -1.757$ (1270)

$MnO_2(s) + 2OH^- + \frac{1}{2}O_2(g) = MnO_4^{--} + H_2O(g)$ (28, 1318)

$MnO_2(s) + 4OH^- = MnO_4^{--} + 2H_2O(l) + 2E^-$
$E^0_{298.1} = -0.50$ (1285); $= -0.66$ (1270)

$MnO_4^{--} = MnO_4^- + E^-$; $E^0_{298.1} = -0.61$ (1285); $= -0.647$ (1270)

$3MnO_4^{--} + 2H_2O(l) = MnO_2(s) + 2MnO_4^- + 4OH^-$
$K_{318.1} = 53$; $E^0_{298.1} = 0.0545$; $\Delta F^0_{318.1} = -2\ 510$ (1270)

$Mn^{++} + H_2O(l) = MnOH^+ + H^+$
At 373.1°K, for $c = 0.25$, % hydrolysis = 0.0017 (800)

$MnCl_2.2H_2O(s) = (?) + xH_2O(g)$ (E); $P_{373.1} = 0.126$ (844)

$MnCl_2.4H_2O(s) = MnCl_2.2H_2O(s) + 2H_2O(g)$ (884) (E)

T	P	T	P
293.1	0.0050	333.1	0.103
303.1	0.024	343.1	0.164
313.1	0.0408	353.1	0.239
323.1	0.0605		

$MnCl_2.NH_3(s) = MnCl_2(s) + NH_3(g)$ (101) (E)

T	P	T	P
484.1	0.0124	545.1	0.125
511.1	0.037	$\Delta H = 20\ 120$ (102)	

$MnCl_2.2NH_3(s) = MnCl_2.NH_3(s) + NH_3(g)$ (101) (E)

T	P	T	P
452.6	0.086	502.1	0.536
480.6	0.258	$\Delta H = 16\ 970$ (102)	

$MnCl_2.6NH_3(s) = MnCl_2.2NH_3(s) + 4NH_3(g)$ (101, 379) (E)

T	P	T	P
332.1*	0.287	353.1	0.618
335.1	0.339	357.1	0.733
338.1	0.303	360.6	0.875
343.1	0.395	363.6	0.987
348.6	0.493	364.1	1.007
350.1*	0.651	$\Delta H = 45\ 320$ (102)	

* From (101); all other values from (379).

$MnCl_2.6CH_3NH_2(s) = (?) + xCH_3NH_2(g)$ (393) (E)

T	P	T	P
314.6	0.224	346.1	1.00 (interp.)
330.1	0.476	352.6	1.243
337.6	0.684	357.6	1.438
345.6	0.955	ΔH = 12 250x	
First decomposition product			
369.6	0.188	395.1	0.658
379.1	0.358	402.6	0.816
388.1	0.517	409.1	0.953
Second decomposition product			
416.6	0.086	448.1	0.263
430.6	0.145	458.1	0.329
438.1	0.197		

$MnCl_2.4C_2H_5NH_2(s) = (?) + xC_2H_5NH_2(g)$ (393) (E)

T	P	T	P
256.1	0.022	277.1	0.497
263.1	0.071	283.6	0.782
267.1	0.141	289.1	1.021
272.6	0.330	295.1	1.349
	ΔH = 10 050x		

$Mn(ClO_4)_2.6H_2O(s) = Mn(ClO_4)_2.4H_2O(s) + 2H_2O(g)$ (1290) (E)

T*	P	T*	P
373.1	0.011	468.1	0.034
383.1	0.018	470.1	0.075
393.1	0.024		

* The compound melts at 388.1°K and changes into the tetrahydrate. Decomposition begins at 423.1°K.

$MnBr_2.H_2O(s) = MnBr_2(s) + H_2O(g)$ (847) (E)

T	P	T	P
413.1	0.074	428.1	0.164
423.1	0.130	433.1	0.205

$MnBr_2.4H_2O(s) = MnBr_2.H_2O(s) + 3H_2O(g)$ (847) (E)

T	P	T	P
293.1	0.0067	373.1	0.263

$MnBr_2.NH_3(s) = MnBr_2(s) + NH_3(g)$ (101) (E)

T	P	T	P
488.1	0.0162	551.1	0.150
503.1	0.0303	ΔH = 20 030	

$MnBr_2.2NH_3(s) = MnBr_2.NH_3(s) + NH_3(g)$ (101) (E)

T	P	T	P
455.1	0.0180	503.1	0.129
488.1	0.0742	ΔH = 18 420	

$MnBr_2.6NH_3(s) = MnBr_2.2NH_3(s) + 4NH_3(g)$ (101, 379) (E)

T	P	T	P
380.1*	0.401	397.1	0.724
383.1	0.405	401.1	0.855
387.6	0.487	403.6	0.947
393.1	0.616	ΔH = 50 720	

* From (101); all other values from (379).

$MnBr_2.6CH_3NH_2(s) = (?) + xCH_3NH_2(g)$ (393) (E)

T	P	T	P
340.6	0.125	385.6	0.936
349.6	0.197	387.1	1.000 (interp.)
362.6	0.361	390.1	1.112
374.1	0.605	395.1	1.309
381.1	0.783	ΔH = 13 850x	
Decomposition products			
382.1	0.050	432.1	0.526
392.6	0.100	444.1	0.724
406.6	0.201	452.6	0.882
422.1	0.383		

$MnBr_2.4C_2H_5NH_2(s) = (?) + xC_2H_5NH_2(g)$ (393) (E)

T	P	T	P
284.1	0.124	305.1	1.00 (interp.)
293.6	0.295	305.6	1.021
298.1	0.463	309.6	1.322
301.6	0.674	ΔH = 10 660x	

$MnI_2.H_2O(s) = MnI_2(s) + H_2O(g)$ (847) (E)

T	P	T	P
393.1	0.171	406.1	0.261
403.1	0.237		

$MnI_2.2H_2O(s) = MnI_2.H_2O(s) + H_2O(g)$ (847) (E)

T	P	T	P
339.1	0.025	383.1	0.120
373.1	0.062	393.1	0.147

$MnI_2.4H_2O(s) = MnI_2.2H_2O(s) + 2H_2O(g)$ (847) (E)

T	P	T	P
323.1	0.007	373.1	0.109
353.1	0.045	383.1	0.178

$MnI_2.6H_2O(s) = MnI_2.4H_2O(s) + 2H_2O(g)$ (E)

$P_{293.1}$ = 0.0049 (847)

$MnI_2.2NH_3(s) = MnI_2(s) + 2NH_3(g)$ (E)

$P_{481.1}$ = 0.0146; $P_{488.1}$ = 0.0192 (101); ΔH = 39 420 (102)

$MnI_2.6NH_3(s) = MnI_2.2NH_3(s) + 4NH_3(g)$ (101, 379) (E)

T	P	T	P
398.6	0.138	429.1	0.479
408.1	0.197	435.6	0.625
416.6	0.296	441.6	0.784
422.6	0.368	446.6	0.947
427.1*	0.416	448.6	1.000 (extrap.)
	ΔH = 56 680 (102)		

* From (101); all other values from (379).

$MnI_2.6CH_3NH_2(s) = (?) + xCH_3NH_2(g)$ (393) (E)

T	P	T	P
343.1	0.076	386.6	0.711
358.1	0.224	395.1	0.987
369.1	0.349	400.1	1.184
378.1	0.509	405.1	1.382
	ΔH = 14 160x		
Decomposition product			
387.6	0.151	427.6	0.875
402.6	0.338	434.1	1.012
416.1	0.616		

$MnI_2.4C_2H_5NH_2(s) = (?) + xC_2H_5NH_2(g)$ (393) (E)

T	P	T	P
285.6	0.133	313.1	0.653
292.6	0.207	318.1	0.913
299.1	0.297	322.6	1.220
304.1	0.392	324.1	1.324
	ΔH = 11 230x		

$MnI_2.6C_2H_5NH_2(s) = MnI_2.4C_2H_5NH_2(s) + 2C_2H_5NH_2(g)$ (393) (E)

T	P	T	P
241.1	0.132	268.1	0.863
253.1	0.397	269.1	0.916
257.6	0.522	273.1	1.103
263.1	0.684	277.1	1.320
	$\Delta H = 18\ 720$		

$MnSO_4(s) = (?) + SO_2(g) + \frac{1}{2}O_2(g)$ (125, 455); *cf.* (636)

T(125)	P	T(455)	P
823–873	1.00	1 308	1.000

$MnSO_4.\frac{1}{2}H_2O(s) = MnSO_4(s) + \frac{1}{2}H_2O(g)$ (E)

$P_{293.11} = 0.00$ (148)

$MnSO_4.H_2O(s) = MnSO_4(s) + H_2O(g)$ (847) (E)

T	P	T	P
293.1	0.004	333.1	0.037
	$\Delta H = 3\ 990$ (1325)		

$MnSO_4.2H_2O(s) = MnSO_4.\frac{1}{2}H_2O(s) + 1\frac{1}{2}H_2O(g)$ (E)

$P_{293.11} = 0.00471$ (148)

$MnSO_4.5H_2O(s) = MnSO_4.H_2O(s) + 4H_2O(g)$ (148, 641, 848, 895); *cf.* (1325) (E)

T	P	T	P
282.1	0.00741	293.1	0.01703
283.1	0.00813	293.1*	0.0149
284.1	0.00895	293.1†	0.0176
285.1	0.00975	298.1‡	0.0261
286.1	0.01060	303.28‡	0.0357
287.1	0.01150	305.57‡	0.0409
287.85	0.01210	306.9§	0.0450
288.1	0.01239	308.27‡	0.0487
288.1	0.01329	309.75‡	0.0532
289.1	0.01422	323.28‡	0.0514
291.1	0.01517	333.1*	0.211
292.1	0.016606		

* From (848). † From (641). ‡ From (257). § From (895); all other values from (148) who states that decomposition results in the dihydrate. According to Linebarger (895), the compound is the tetrahydrate instead of the pentahydrate.

$MnSO_4.5H_2O$ and $CuSO_4.5H_2O$ (mixed crystals) (641) (E)

Mole % $MnSO_4$	P at T = 293.1 ± 0.02	Mole % $MnSO_4$	P at T = 293.1 ± 0.02
100.0	0.0176	14.9	0.0050
97.8	0.0167	8.0	0.0049
93.9	0.0158	3.3	0.0058
84.4	0.0155	0.0	0.0076
23.3	0.0063		

$MnSO_4.5H_2O$ and $ZnSO_4.7H_2O$ (mixed crystals) (641) (E)

% = Mole % $MnSO_4$; P is measured at 293.1 ± 0.02°K

Rhombic $7H_2O$		Monoclinic $7H_2O$		Triclinic $5H_2O$	
%	P	%	P	%	P
0.0	0.0138	36.4	0.0149	90.4	0.0166
1.9	0.0137	46.5	0.0153	95.8	0.0172
5.2	0.0136	58.3	0.0157	100.0	0.0176
10.6	0.0134	67.2	0.0163		
16.3	0.0134	70.2	0.0167		
24.0	0.0136				

$MnSO_4.7H_2O(s) = MnSO_4.5H_2O(s) + 2H_2O(g)$ (E)

$P_{287.85} = 0.01387$ (148)

$MnSO_4.2NH_3(s) = (?) + xNH_3(g)$ (380) (E)

T	P	T	P
375.1	0.096	401.6	0.171
387.1	0.130		

$MnSO_4.6NH_3(s) = MnSO_4.2NH_3(s) + 4NH_3(g)$ (380) (E)

T	P	T	P
323.6	0.343	344.4	0.914
329.6	0.450	346.6	1.000 (extrap.)
338.1	0.626	$\Delta H = 49\ 160$	

$(NH_4)_2Mn(SO_4)_2.6H_2O(s) = (NH_4)_2Mn(SO_4)_2.2H_2O(s) + 4H_2O(g)$ (399) (E)

T	P	T	P
339.1	0.203	355.1	0.437
346.1	0.272	358.1	0.488
348.1	0.311	363.1	0.587
352.1	0.372		

$MnNH_4PO_4.7H_2O(s) = MnNH_4PO_4(aq) + 7H_2O(l)$ (1517)

$MnCO_3(s) + CO_2(g) + H_2O(l) = Mn^{++} + 2HCO_3^-$ (564)

At 291.1°K

P	$m_{(Mn^{++})}$	P	$m_{(Mn^{++})}$
1	0.00348	56	0.00696

$MnCO_3(s) = MnO(s) + CO_2(g)$ (946) (E)

$MnCO_3$ is always deposited hydrated and cannot be dehydrated without almost complete decomposition. The value of the CO_2 pressure depends upon the amount of retained water and is reproducible for equal amounts of water. For example, for 2.5% water, $P = 0.0012$ atm. at $T = 523.1$°K, and for 2.0% water, $P = 0.004$ atm. at $T = 523.1$°K. The following data are for a mineral containing 4.63% FeO, 39.63% MnO, 12.98% MgO, 0.074% SiO_2 and 41.63% CO_2:

T	P	T	P
523.1	0.0099	623.1	0.075
573.1	0.022	648.1	0.149
598.1	0.026		

Friedrich (453) finds for Rhodocrosite from Colorado a pressure of 1 atm. at $T = 798.1$°K. For manganese-bearing dolomites, *see* (525).

$Mn(OH)_3(s) + 3HCN(aq) + 3CN^- = Mn(CN)_6^{---} + 3H_2O(l)$

$K = 0.25 \times 10^7$ (990)

$Mn(C_6H_5CO_2)_2.8NH_3(s) = (?) + xNH_3(g)$ (383) (E)

T	P	T	P
263.1	0.297	283.1	0.947
273.1	0.524	283.6	1.000
282.1	0.855		

$2MnO_2(s) = Mn_2O_3(s) + \frac{1}{2}O_2(g)$ (27, 995); *cf.* (451, 504.5)

T	P	T	P
655.1	0.030	803.1 (995)	0.209
721.1	.164	809.1	1.36
751.1	.263	1 213.1 (995)	1.000

$Mn_3O_4(s) + H_2(g) = 3MnO(s) + H_2O(g)$; $K_{723.1} = 34.6$ (1538); *cf.* (46, 491)

$3Mn_2O_3(s) = 2Mn_3O_4(s) + \frac{1}{2}O_2(g)$ (995); *cf.* (451, 1321)

T	P	T	P
1 213.1	0.209	1 363.1	1.000

$AgMnO_4$; *see* p. 272

Fe, Iron

Fe^{++}; $E^0_{298.1} = 0.441$; $\Delta F^0_{298.1} = -20\ 350$ (885). $\Delta F^0_{298.1} = -20\ 240$ (1179), revised value

$Fe(s) + 2HgCl(s) = Fe^{++} + 2Cl^- + 2Hg(l)$

$E^0_{298.1} = 0.7061$; $\Delta F^0_{298.1} = -32\ 585$; $\text{Const.}_{298.1} = -7.9750$ (569, 1179); *cf.* (1216)

$Fe(s) + 2TlCl(s) = Fe^{++} + 2Cl^{-} + 2Tl(s)$ (1179) *from* (569)

$\Delta F^0_{298.1} = 5\ 455$

$m_{(Fe^{++})}$	$m_{(Tl^{+})}$	$m_{(Cl^{-})}$	$\log m^{1/3}$	$\mu^{1/2}$
0.0453	0.0042	0.0948	−1.1301	0.3743

Fe^{+++}; $\Delta F^0_{298.1} = -3\ 120$ (885)

$2Fe^{+++} + 2I^{-} = 2Fe^{++} + I_2(aq)$ (210)

$2Fe^{++} + H_3AsO_4(aq) + 2H^{+} = 2Fe^{+++} + H_3AsO_3(aq) + H_2O(l)$

T (702)........	290.1	380.1	400.1
K.............	2.1×10^{-5}	0.0354 ± 15%	0.117 ± 20%

$Cu^{++} + Fe^{++} + H_2O(l) + F^{-} = CuOH(s) + HF(aq) + Fe^{+++}$ (1022)

$Fe^{++} + Ag^{+} = Ag(s) + Fe^{+++}$

$K_{298.1} = 0.128$; $E^0_{298.1} = -0.0528$ (1079); $\Delta F^0_{298.1} = 1\ 218$ (885); *cf.* (359, 776, 1141, 1425)

$FeO(s) + H_2(g) = Fe(s) + H_2O(g)$ (361); *cf.* (360, 491, 963)

T	K	T	K
951.1	0.56	1 138.1	0.78
998.1	.61	1 182.1	.84
1 045.1	.67	1 225.1	.88
1 091.1	.73	1 295.1	.96

$FeO(s) + CO(g) = Fe(s) + CO_2(g)$ (360); *cf.* (63, 258, 405, 406, 407, 408, 465, 1070, 1309, 1315, 1431, 1473)

T	K	T	K
873.1	0.871	1 173.1	0.466
973.1	0.678	1 273.1	0.403
1 073.1	0.552		

$FeCl_2(l) + H_2(g) = Fe(s) + 2HCl(g)$ (40)

$FeCl_2(aq)$ (1179) *from* (91, 504, 569, 1133, 1419)

m	$\log \gamma$	m	$\log \gamma$
0.001	−0.048	0.05	−0.205
.002	−0.065	.1	−0.236
.005	−0.095	.2	−0.252
.01	−0.124	.5	−0.234
.02	−0.157	1.0	−0.175

$FeCl_2.H_2O(s) = FeCl_2(s) + H_2O(g)$ (E); $P_{428.1} = 0.072$ (847)

$FeCl_2.2H_2O(s) = FeCl_2.H_2O(s) + H_2O(g)$ (847) (E)

T	P	T	P
363.1	0.039	393.1	0.171
373.1	0.063	398.1	0.247
383.1	0.099		

$FeCl_2.NH_3(s) = FeCl_2(s) + NH_3(g)$ (101, 102) (E)

T	P	T	P
487.6	0.0076	550.1	0.0716
503.1	0.014	564.1*	0.132 (extrap.)
	$\Delta H = 20\ 760$*		

* From (102); all other values from (101).

$FeCl_2.2NH_3(s) = FeCl_2.NH_3(s) + NH_3(g)$ (101, 102, 490) (E)

T	P	T	P
369.1	0.001	485.1	0.149
408.1	0.007	498.1*	0.132 (extrap.)
416.1	0.008	503.1†	0.159
430.1	0.014	508.1	0.291
433.1	0.017	528.1	0.497
439.1	0.025	530.1	0.546
447.1	0.036	534.1	0.625
455.1	0.050	543.1	0.791
459.1	0.055	550.1†	0.730
478.1	0.082	545.1	0.957

* From (102). † From (101); all other values from (490).

$FeCl_2.6NH_3(s) = FeCl_2.2NH_3(s) + 4NH_3(g)$ (102, 383, 490) (E)

T	P	T	P
287.1	0.007	356.1	0.250
307.1	0.011	358.6*	0.267
319.1	0.012	366.1*	0.355
323.1	0.014	368.1	0.437
328.1	0.033	373.1	0.559
329.1	0.038	373.6*	0.493
337.6*	0.108	375.1	0.611
338.1	0.084	378.8*	0.645
343.1	0.122	379.1	0.741
344.1†	0.132	381.9*	0.720
347.1	0.153	385.6*	0.849
348.1*	0.171	388.1*	0.941
353.1	0.197	388.1	0.978
	ΔH† = 49 000		

* From (383). † From (102); all other values from (490).

$FeCl_2.5CH_3NH_2(s) = (?) + xCH_3NH_2(g)$ (393) (E)

T	P	T	P
332.1	0.167	370.1	1.00 (interp.)
344.6	0.366	371.6	1.055
353.6	0.558	378.1	1.305
363.1	0.795	$\Delta H = 13\ 180x$	

$2FeCl_3(?) = 2FeCl_2(s) + Cl_2(g)$

$P_{564.6} = 0.0317$; $P_{574.9} = 0.0420$ (937)

$FeCl_3.6H_2O(s) = FeCl_3.3\frac{1}{2}H_2O(s) + 2\frac{1}{2}H_2O(g)$ (E)

$P_{288.1} = 0.0024$ (1253)

$FeCl_3.6NH_3(s) = (?)$ (Solid solution) $+ xNH_3(g)$ (395) (E)

T	P	T	P
300.6	0.147	331.1	0.616
311.4	0.263	338.1	0.771
322.1	0.426	343.6	0.939

$FeCl_3.12NH_3(s) = (?) + xNH_3(g)$ (E)

$P_{194.1} = 0.0118$ (652)

$FeBr_2.H_2O(s) = FeBr_2(s) + H_2O(g)$ (E)

$P_{433.1} = 0.257$ (847)

$FeBr_2.2H_2O(s) = FeBr_2.H_2O(s) + H_2O(g)$ (847) (E)

T	P	T	P
383.1	0.118	403.1	0.276
393.1	0.158		

$FeBr_2.NH_3(s) = FeBr_2(s) + NH_3(g)$ (101, 102) (E)

T	P	T	P
488.1	0.0075	550.1	0.0809
503.1	0.0128	564.6*	0.132 (interp.)
	$\Delta H = 20\ 780$*		

* From (102); all other values from (101).

$FeBr_2.2NH_3(s) = FeBr_2.NH_3(s) + NH_3(g)$ (101, 102) (E)

T	P	T	P
488.1	0.0151	514.1*	0.132 (interp.)
503.1	0.0309	550.1	0.166
	$\Delta H = 19\ 870$*		

* From (102); all other values from (101).

$FeBr_2.6NH_2(s) = FeBr_2.2NH_3(s) + 4NH_3(g)$ (101, 102, 383) (E)

T	P	T	P
336.1	0.029	388.4	0.230
348.1	0.045	396.6	0.311
358.6	0.063	403.6	0.433
369.6	0.100	416.1	0.714
378.6	0.150	422.1	0.899
380.1	0.166	426.1	1.019
	$\Delta H = 53\ 360$ (102)		

$FeBr_2.5CH_3NH_2(s) = (?) + xCH_3NH_2(g)$ (393) (E)

T	P	T	P
358.1	0.100	398.6	0.882
365.6	0.145	401.1	1.000 (interp.)
374.1	0.262	403.6	1.087
383.1	0.434	409.1	1.313
390.6	0.629	$\Delta H = 14\ 400x$	

$FeBr_3.6NH_3(s) = (?)$ (Solid solution) $+ xNH_3(g)$ (E)

$P_{318.1} = 1.000$; $\Delta H =$ *ca.* $11\ 200x$ (395)

$FeI_2.H_2O(s) = FeI_2(s) + H_2O(g)$ (E)

$P_{433.1} = 0.145$ (847)

$FeI_2.2H_2O(s) = FeI_2.H_2O(s) + xH_2O(g)$ (847) (E)

T	P	T	P
363.1	0.101	383.1	0.211
373.1	0.151	393.1	0.306

$FeI_2. > 2H_2O(s) = FeI_2.2H_2O(s) + xH_2O$ (E)

Vapor pressures very similar to those of saturated solution (847)

$FeI_2.2NH_3(s) = FeI_2(s) + 2NH_3(g)$ (101, 102) (E)

T	P	T	P
488.1	0.0080	551.1	0.112
504.1	0.0159	560.1*	0.132 (extrap.)
	$\Delta H = 40\ 920$*		

* From (102); all other values from (101).

$FeI_2.6NH_3(s) = FeI_2.2NH_3(s) + 4NH_3(g)$ (101, 102, 383) (E)

T	P	T	P
385.1	0.082	437.1	0.467
398.1	0.116	445.6	0.628
408.1*	0.132	450.6	0.746
408.6	0.151	453.6	0.822
418.6	0.237	457.1	0.932
426.1*	0.271	460.6	1.053
429.6	0.363	$\Delta H = 58\ 000$ (102)	

* From (101, 102); all other values from (383).

$FeI_2.5CH_3NH_2(s) = (?) + xCH_3NH_2(g)$ (393) (E)

T	P	T	P
360.6	0.099	404.1	0.875
376.1	0.230	407.1	1.000 (interp.)
385.6	0.380	409.1	1.055
393.6	0.566	415.1	1.284
398.1	0.692	$\Delta H = 14\ 630x$	

$FeSO_4.H_2O(s) = FeSO_4(s) + H_2O(g)$ (E)

$P_{293.1} = 0.0026$; $P_{333.1} = 0.049$ (848)

$FeSO_4.7H_2O(s) = FeSO_4.6H_2O(s) + H_2O(g)$ (291, 292, 1335); *cf.* (1325) (E)

T	P	T	P
298.1*	0.01915	317.55	0.06495
303.77	0.04301	318.53	0.10106
313.06	0.07203		

* From (1335); all other values from (291, 292).

$ZnSO_4.7H_2O$ and $FeSO_4.7H_2O$ (mixed crystals) $= (?) + xH_2O(g)$ (E)

For mixed crystals with from 37.45 to 96.28% $FeSO_4$, each compound as if uninfluenced by the other is dehydrated to the hexahydrate (1241). Similar data also given for the rhombic mixed crystals

$FeSO_4.6NH_3(s) = FeSO_4.4NH_3(s) + 2NH_3(g)$ (384) (E)

T	P	T	P
346.1	0.197	361.6	0.461
355.1	0.337	367.6	0.611

$FeSO_4.6NH_3(s)$.—*(Continued)*

T	P	T	P
371.6	0.725	380.1	0.974
375.6	0.845	382.6	1.037
	$\Delta H = 27\ 300$		
	First decomposition product		
369.1	0.349	387.1	0.947
379.1	0.643	387.6	1.019
384.6	0.814		
	Second decomposition product		
373.6	0.246	401.1	0.647
386.6	0.484	413.6	0.743
391.6	0.555	432.6	0.841

$Fe^{++} + NO(g) = Fe(NO)^{++}$ (944)

$NH_4Fe(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (399) (E)

T	P	T	P
298.1	0.008	314.1	0.051
306.1	0.024		

$FeCO_3(s) + H_2CO_3(aq) = Fe^{++} + 2HCO_3^-$ (1191) *from* (1369)

$\log p.f._{303.1} = 2.226$; $\Delta F^0_{303.1} = 9\ 268$; $\Delta H = -6\ 270$; $\Delta F^0_{298.1} = 9\ 011$

$c_{(H_2CO_3)}$	$c_{(Fe^{++})}$	$c_{(HCO_3^-)}$	$\mu_c^{1/2}$	$\log (1/K_c^{1/3})$
0.1868	0.00245	0.00490	0.086	2.1673
.1985	.00257	.00514	.088	2.1553
.2168	.00262	.00524	.089	2.1596
.2327	.00274	.00548	.091	2.1505
.2960	.00303	.00606	.095	2.1416
.3116	.00304	.00608	.096	2.1476
.3294	.00311	.00622	.097	2.1460
.3745	.00315	.00630	.097	2.1587
.3153	.00318	.00636	.098	2.1298
.4046	.00332	.00664	.100	2.1471
.4750	.00348	.00696	.102	2.1498
.6600	.00402	.00804	.110	2.1350
.7154	.00418	.00836	.112	2.1298
.7600	.00434	.00868	.114	2.1222

$FeCO_3(s) + CO_2(g) + H_2O(l) = Fe^{++} + 2HCO_3^-$ (1191) *from* (565)

At 291.1°K, $\mu^{1/2} = 0.136$; $p_{CO_2} = 1$; $\log (1/K_m)^{1/3} = 2.004$; $\log p.f. = 2.108$; $\Delta F^0_{291.1} = 8\ 429$; $\Delta H = -11\ 170$; $\Delta F^0_{298.1} = 8\ 900$; values probably too high

$Fe(HCO_3)_2(s) = Fe^{++} + 2HCO_3^-$

$\Delta F^0_{291.1} = 8\ 336$ (1191) *from* (565)

$FeCO_3(s) = FeO(s) + CO_2(g)$ (E)

At $T =$ *ca.* 653°K, $P = 1$ atm., from Ivigtut and Neudorf; at $T =$ *ca.* 688°K, $P = 1$ atm., ppt. $FeCO_3$ (453)

$CH_3NH_2.Fe(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (1026) (E)

T	P	T	P
295.6	0.0059	307.6	0.033
298.1	0.009	308.1	0.0380
300.6	0.013	310.1	0.039
303.1	0.0191	313.1	0.051
305.1	0.024	315.1	0.062

$(NH_4)_3Fe(C_2O_4)_3.4H_2O(s) = (NH_4)_3Fe(C_2O_4)_3(s) + 4H_2O(g)$ (E)

$P_{298.1} = 0.0024 - 0.0058$ (916)

$(NH_4)_3Fe(C_2O_4)_3.5H_2O(s) = (NH_4)_3Fe(C_2O_4)_3.4H_2O(s) + H_2O(g)$ (E)

$P_{298.1} = 0.0058 - 0.0116$ (916)

$(NH_4)_3Fe(C_2O_4)_3.6H_2O(s) = (NH_4)_3Fe(C_2O_4)_3.5H_2O(s) + H_2O(g)$ (E)

$P_{298.1} = 0.0116 - 0.0176$ (916)

$Fe(s) + 5CO(g) = Fe(CO)_5(g)$ (1408); *cf.* (1015)
$T = 353.1°K$

P_{CO}	$P_{Fe(CO)_5}$	$\log K$
0.579	0.00120	−1.734
.737	.00314	−1.841
.868	.00762	−1.811
.918	.00799	−1.912
.963	.0100	−1.918
1.121	.0200	−1.947
1.126	.0207	−1.942
1.270	.0339	−2.002
1.479	.0586	−2.082

$Fe(C_6H_5CO_2)_2.6NH_3(s) = (?)$ (Solid solution) $+ xNH_3(g)$ (E)
$P_{287.1} = 0.618$ (383)

$Fe(C_6H_5CO_2)_2.8NH_3(s) = (?)$ (Solid solution) $+ xNH_3(g)$ (E)
$P_{280.1} = 1.00$ (383)

$Fe(C_{10}H_7SO_3)_2.8NH_3(s) = (?)$ (Solid solution) $+ xNH_3(g)$ (E)
$P_{283.1} = 1.00$ (383)

$Zn[Fe(NO)(CN)_5].8NH_3(s) = Zn[Fe(NO)(CN)_5].4NH_3(s) + 4NH_3(g)$ (1457) (E)

T	P	T	P
252.1	0.376	269.1*	0.825
258.1	0.536	272.1	0.928
264.1	0.687		

* The decomposition results in solid solutions. For the pure compound $P = 1.00$ at *ca.* 268.1°K.

$Zn_2[Fe(CN)_6].6H_2O(s) = (?) + xH_2O(g)$ (916) (E)
Loss in weight over H_2SO_4 determined

P	Moles H_2O	P	Moles H_2O
0.02838	2.45	0.00580	4.18
0.02579	3.14	0.00230	4.72
0.02319	3.32	0.00074	5.44
0.01769	3.60	0.0003	5.96
0.0116	3.90	0.0000	5.96

$Cu_2[Fe(CN)_6].10H_2O(s) = (?) + xH_2O(g)$ (916) (E)
Loss in weight over H_2SO_4 determined

P	Moles H_2O	P	Moles H_2O
0.02838	0.95	0.00580	7.14
0.02579	2.28	0.00230	7.82
0.02319	3.60	0.00074	8.74
0.01769	4.92	0.0003	9.30
0.0116	6.14	0.0000	9.77

$Fe_2(SO_4)_3(s) = (?) + SO_2(g) + \frac{1}{2}O_2(g)$ (138, 1540); *cf.* (453, 636)

T	P	T	P
909.1*	0.129	953.1	0.333
919.1	.093	953.1*	.331
948.1	.290	973.1	.586
948.1*	.291	994.1	.987

* From (138); all other values from (1540).

$Fe_2(SO_4)_3.12NH_3(s) = (?)$ (Solid solution) $+ xNH_3(g)$ (395) (E)

T	P	T	P
273.1	0.105	302.4	0.625
281.6	0.167	309.1	0.928
288.3	0.255	310.1	0.980
295.3	0.382	$\Delta H = 10\ 900x$	

$Fe_2N(s) = 2Fe(s) + \frac{1}{2}N_2(g)$ (1087)

$P_{733.1}$............	20 000	102 000	590 000	41 000
Solid phase, atomic ratio Fe/N....	17:1 to 9:1	7.7:1	4.9:1	2.6:1

$2Fe_2N(s) + 3H_2(g) = 4Fe(s) + 2NH_3(g)$ (1087); *cf.* (65, 442, 964, 1010.5, 1521)

$K_{733 \pm 5}$	Atomic ratio, Fe/N in solid phase	$K_{733 \pm 5}$	Atomic ratio, Fe/N in solid phase
1.0	17.1	5.2	7.72
0.8	9.5	30	4.87
1.2	9.0	2.1	2.59

Fe_3O_4 (in satd. $FeO(s)$) $= 3FeO$ (in satd. $Fe_3O_4(s)$) $+ \frac{1}{2}O_2(g)$ (1394); *cf.* (457, 1273)

%FeO in solid	P_{1373}	P_{1473}
0.90	0.00049	0.0066
1.80	.00029	.0047
2.71	.00022	.0039
4.52	.00017	.0034
9.09	.00013	.00283
13.70	.00012	.00236
18.37	.000111	.00204
23.07	.000091	.00167
27.83	.000068	.00112
31.03	<.000006	<.00005

$Fe_3O_4(s) + H_2(g) = 3FeO(s) + H_2O(g)$ (361); *cf.* (332, 333, 360, 415, 491, 516.5, 632, 1156, 1332, 1538, 1541, 1542)

T	K	T	K
951.1	1.27	1 138.1	4.60
998.1	1.93	1 182.1	5.52
1 045.1	2.68	1 225.1	6.75
1 091.1	3.54	1 295.1	8.3

$Fe_3O_4(s) + CO(g) = 3FeO(s) + CO_2(g)$ (361); *cf.* (63, 163, 360, 405, 790, 963, 1307)

T	K	T	K
1 091.1	2.71, 2.49	1 225.1	3.61
1 138.1	2.83	1 312.1	4.35, 4.50, 4.56

$3Fe_2O_3(s) = 2Fe_3O_4(s) + \frac{1}{2}O_2(g)$ (1486); *cf.* (1394)

T	P	T	P
1 373	0.0066	1 613	0.182
1 423	.0092	1 623	.218
1 473	.0118	1 633	.266
1 523	.0263	1 653	.391
1 573	.0782	1 663	.464
1 593	.119	1 773	.597

Co, Cobalt

$Co(s) = Co^{++} + 2E^-$
$E^0_{298.1} = -0.255$ (812); *cf.* (1061); $= -0.262$ (804); $= -0.307$ (1317); $= -0.292$ (288)

$Co^{++} = Co^{+++} + E^-$
$E^0_{273.1} = -1.779$; $E^0_{298.1} = -1.817$ (812); *cf.* (689, 1094)

$CoO(s) + H_2(g) = Co(s) + H_2O(g)$ (1538); *cf.* (277, 491)

T	K	T	K
728	14	1 023	19

$Co^{++} + H_2O(l) = CoOH^+ + H^+$ (800)

c	% Hydrolysis			
	In $CoCl_2(aq)$		In $Co(NO_3)_2(aq)$	
	358.6°K	373.0°K	358.6°K	373.0°K
0.0156	0.0147	0.0196	0.0152	0.0154
.0625	.0173	.0172	.00328	.0048

$CoCl_2(s) + H_2(g) = Co(s) + 2HCl(g)$ (314)

$CoCl_2.6H_2O(s) = CoCl_2.2H_2O(s) + 4H_2O(g)$ (331); *cf.* (843, 844) (E)

T	P	T	P
293.1	0.0071*	313.1	0.0279*
296.15	0.0084	317.02	0.0366
297.29	0.0089	318.1	0.0389*
298.1	0.0095*	319.94	0.0438
301.78	0.0126	321.7	0.0505
303.1	0.0134*	322.33	0.0522
305.75	0.0163	323.1	0.0550
308.1	0.0196*	324.68	0.0613
309.08	0.0217	325.35†	0.0639†
312.57	0.0270		

* Interpolated. † Transition point.

$CoCl_2.NH_3(s) = CoCl_2(s) + NH_3(g)$ (96) (E)

T	P	T	P
481.1	0.00376	503.1	0.01059
488.1	0.00495	ΔH = 21 100 (102)	

$CoCl_2.2NH_3$(α-form) (s) $= CoCl_2.NH_3(s) + NH_3(g)$ (96) (E)

T	P	T	P
409.6	0.0091	503.1	0.1084
426.6	0.0175	507.1	0.1121
441.1	0.0355	509.7	0.1183
456.6	0.0559	ΔH = 18 670 (102)	

$CoCl_2.6NH_3(s) = CoCl_2.2NH_3(s) + 4NH_3(g)$ (E)

T(102)	P	T(96)	P
362.1	0.132	410.1	1.053
	ΔH = 51 600 (102)		

On rapid heating to 430.1°K, no mixed crystals form. On slow heating mixed crystals of the formula $CoCl_2.6NH_3.2\frac{31}{100}CoCl_2.2NH_3$ appear between 425.1 and 448.1°K. Disregarding mixed crystals, Ephraim (379) obtained the following results:

T	P	T	P
355.6	0.099	399.1	0.559
365.6	0.133	405.1	0.708
374.6	0.205	409.1	0.816
384.1	0.304	412.6	0.925
391.1	0.401		

$CoCl_2.6CH_3NH_2(s) = (?) + xCH_3NH_2(g)$ (393) (E)

T	P	T	P
333.1*	0.197	370.6	0.822
345.6	0.349	376.1	0.987
355.6	0.520	381.1	1.171
363.1	0.664	ΔH = 13 420x	
	Decomposition product		
377.1	0.074	406.6	0.221
387.6	0.109	423.6	0.358
401.6	0.186	433.1	0.446

* The compound melts at 323.1°K.

$CoCl_2.4C_2H_5NH_2(s) = (?) + xC_2H_5NH_2(g)$ (393) (E)

T	P	T	P
285.1	0.145	303.1	0.537
294.1	0.270	307.1	0.724
309.6	0.921	312.6	1.250
311.1	1.086	ΔH = 10 850x	

$Co(ClO_4)_2.6H_2O(s) = (?) + xH_2O(g)$ (1290) (E)

T	P	T	P
360.1	0.021	455.1	0.0547
403.1	0.042	470.1	0.0649
418.1	0.0518	480.1	0.079
426.1	0.0547	485.1	0.124
443.1*	0.0547	493.1	0.337

* Decomposition begins at 453.1°K.

$Co(ClO_4)_2.6NH_3(s) = (?) + xNH_3(g)$ (1290) (E)

T	P	T	P
350.1	0.0100	400.1	0.0901
370.1	0.0259	410.1	0.1280
380.1	0.0359	421.1*	0.1737
390.1	0.0561		

* Decomposition begins at 421.1°K.

$CoBr_2(s) + H_2(g) = Co(s) + 2HBr(g)$ (314)

$CoBr_2.NH_3(s) = CoBr_2(s) + NH_3(g)$ (96) (E)

T	P	T	P
434.5	0.00038	461.7	0.00161
454.9	0.00130	481.5	0.00468
	ΔH = 21 000 (102)		

$CoBr_2.2NH_3(s) = CoBr_2.NH_3(s) + NH_3(g)$ (96) (E)

T	P	T	P
425.5	0.00057	454.9	0.00268
433.6	0.000914	ΔH = 20 170 (102)	

$Co.Br_2.6NH_3(g) = CoBr_2.2NH_3(s) + 4NH_3(g)$ (379) (E)

T*	P	T*	P
377.1	0.097	432.6	0.533
386.1	0.117	438.1	0.649
394.6	0.145	443.6	0.776
404.6	0.184	448.1	0.900
415.1	0.272	449.6	0.958
423.1	0.367	451.1	1.000 (extrap.)

* According to Biltz and Fetkenheuer (96), the decomposition results in an unbroken series of mixed crystals. For the pure substance, P = 0.132 at T = 394.1 (102); P = 0.262 at T = 409.9 (96); ΔH = 56 000 (102).

$CoBr_2.6CH_3NH_2(s) = (?) + xCH_3NH_2(g)$ (393) (E)

T	P	T	P
347.6	0.084	387.6	0.491
355.6	0.109	398.6	0.821
366.1	0.166	404.6	1.034
376.6	0.279	410.6	1.268
	ΔH = 14 470x		

$CoBr_2.4C_2H_5NH_2(s) = (?) + xC_2H_5NH_2(g)$ (393) (E)

T	P	T	P
303.6	0.122	335.1	0.830
315.1	0.255	338.6	0.989
325.6	0.488	343.1	1.220
330.6	0.666	ΔH = 12 210x	

$CoI_2.2NH_3(s) = CoI_2(s) + 2NH_3(g)$ (96, 102) (E)

T (96)	P	T (102)	P
409.6	0.00022	545.1	0.132 (extrap.)
426.6	0.00123	ΔH = 39 800 (102)	

$\mathbf{CoI_2.6NH_3(s) = y(CoI_2.6NH_3)(CoI_2.2NH_3)_{1.15}(s) + xNH_3(g)}$ (96, 102) (E)

T	P	T	P
410.1	0.087	454.1	0.600
414.1*	0.132	ΔH = 14 700x*	

* From (102); all other values from (96). Somewhat smaller values of pressure, which disregard mixed crystals, are given by (379).

$\mathbf{y(CoI_2.6NH_3)(CoI_2.2NH_3)_{1.15}(s) = CoI_2.2NH_3(s) + xNH_3(g)}$ (96) (E)

T	P	T	P
410.1	0.060	454.6	0.374

$\mathbf{CoI_2.6CH_3NH_2(s) = (?) + xCH_3NH_2(g)}$ (393) (E)

T	P	T	P
368.1	0.093	413.1	0.571
377.1	0.128	418.6	0.687
389.6	0.207	423.6	0.796
394.1	0.257	431.1	0.993
399.6	0.330	436.1	1.175
408.1	0.480	ΔH = 15 580x	
Decomposition product			
377.1	0.074	406.6	0.221
387.6	0.119	423.6	0.358
401.6	0.186	433.1	0.446

$\mathbf{CoI_2.4C_2H_5NH_2(s) = (?) + xC_2H_5NH_2(g)}$ (393) (E)

T	P	T	P
313.6	0.068	349.1	0.671
324.1	0.158	355.1	0.863
331.6	0.266	360.1	1.057
338.6	0.400	364.6	1.249
	ΔH = 12 750x		

$\mathbf{CoI_2.6C_2H_5NH_2(s) = CoI_2.4C_2H_5NH_2(s) + 2C_2H_5NH_2(g)}$ (393) (E)

T	P	T	P
256.1	0.132	280.6	0.789
263.1	0.236	284.1	0.921
268.1	0.384	286.6	1.053
273.2	0.553	291.6	1.276
276.6	0.658	ΔH = 21 860	

$\mathbf{CoSO_4(s) = (?) + SO_2(g) + \tfrac{1}{2}O_2(g)}$ (636)

$\mathbf{CoSO_4.H_2O(s) = CoSO_4(s) + H_2O(g)}$ (848) (E)

T	P	T	P
290.1	0.0157	333.1	0.228
293.1	0.0180	353.1	0.388

$\mathbf{CoSO_4.7H_2O(s) = CoSO_4.6H_2O(s) + H_2O(g)}$ (257, 1335) (E)

T	P	T	P
298.1*	0.02181	309.75	0.050
298.1	0.0224	313.32	0.0637
305.6	0.0378	318.16	0.087

* From (1335); all other values from (257).

$\mathbf{CoSO_4.2NH_3(s) = (?) + xNH_3(g)}$ (E)

$P_{420.1} = 0.053$ (379, 380, 381)

$\mathbf{CoSO_4.4NH_3(s) = (?) + xNH_3(g)}$ (379, 380, 381) (E)

T	P	T	P
376.6	0.186	397.1	0.583
385.6	0.337	404.6	0.855
386.6*	0.276	408.1*	0.863
397.1*	0.532	409.1	1.080
	ΔH = 14 780x		

* Substance previously heated for a long time.

$\mathbf{CoSO_4.6NH_3(s) = (?) + xNH_3(g)}$ (380) (E)

T	P	T	P
339.1	0.114	375.6	0.637
353.6	0.229	379.1	0.708
363.1	0.384	382.6	0.784
371.6	0.545	389.6	1.000 (extrap.)
	ΔH = 13 980x		

$\mathbf{CoS_2O_6.6NH_3(s) = (?) + xNH_3(g)}$ (398) (E)

T	P	T	P
373.6	0.116	414.6	0.599
384.1	0.175	423.1	0.803
394.1	0.264	430.1	0.974
406.6	0.437	430.6	1.000

$\mathbf{Co(NO_3)_2(aq) = (?) + xH_2O(g)}$ (848) (E)

$\mathbf{Co(NO_3)_2.6NH_3(s) = (?) + xNH_3(g)}$ (398) (E)

T	P	T	P
294.1	0.017	425.1	0.620
382.6	0.170	426.1	0.704
404.1	0.275	430.6	0.855
410.6	0.357	433.1	1.000 (extrap.)

$\mathbf{(NH_4)_2Co(SO_4)_2.6H_2O(s) = (NH_4)_2Co(SO_4)_2.2H_2O(s) + 4H_2O(g)}$ (265) (E)

$\Delta H = 59\ 200;\ \log P = 4.719 + 843.4/T - 388\ 300/T^2$

T	P	T	P
308.4	0.0075	327.1	0.0339*
310.6	0.0095*	334.8	0.0542
316.9	0.0155	340.4	0.0772
320.2	0.0204*	355.3	0.1854
323.8	0.0254		

* Measured on cooling.

$\mathbf{NH_4Co(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)}$ (1026) (E)

T	P	T	P
288.1	0.0086	303.1	0.0664
295.6	0.0256	308.6	0.1197
301.1	0.053		

$\mathbf{[Co(NH_3)_4(H_2O)_2]^{+++}(0.077\mathit{M})}$ **(diaquotetramminecobaltic chloride)** $\mathbf{+ \tfrac{1}{2}H_2(g) + 2H_2O(l) = Co^{++}(0.019\mathit{M}) + H^+ + 4NH_4OH(3.256\mathit{M})}$

$E_{298.1} = 0.1034$ (812)

$\mathbf{[Co(NH_3)_5H_2O]^{+++}(0.077\mathit{M})}$ **(aquopentamminecobaltic chloride)** $\mathbf{+ \tfrac{1}{2}H_2(g) + 4H_2O(l) = Co^{++}(0.019\mathit{M}) + H^+ + 5NH_4OH(3.256\mathit{M})}$

$E_{298.1} = 0.0884$ (812)

$\mathbf{[CoCl(NH_3)_5]Cl_2(aq)}$ **(purpureocobaltic chloride)** $\mathbf{+ H_2O(l) = [Co(NH_3)_5H_2O]Cl_3(aq)}$ **(roseocobaltic chloride)**

$K_{373.1} = 1.4$ (1130)

$\mathbf{[CoNO_2(NH_3)_5]^{++}(0.015\mathit{M})}$ **(nitritopentamminecobaltic chloride)** $\mathbf{+ \tfrac{1}{2}H_2(g) + 6H_2O(l) = Co^{++}(0.019\mathit{M}) + H^+ + 5NH_4OH\ (3.256\mathit{M}) + NO^-(?)}$

$E_{298.1} = 0.0929$ (812)

$\mathbf{[Co(NO_2)_2(NH_3)_4]^+(0.015\mathit{M})}$ **(1, 2-dinitritotetramminecobaltic chloride)** $\mathbf{+ \tfrac{1}{2}H_2(g) + 6H_2O(l) = Co^{++}\ (0.019\mathit{M}) + H^+ + 2NO_2^-(?) + 4NH_4OH(3.256\mathit{M})}$

$E_{298.1} = 0.0674$ (812)

$\mathbf{[Co(NO_2)_2(NH_3)_4]^+(0.015\mathit{M})}$ **(1, 6-dinitritotetramminecobaltic chloride)** $\mathbf{+ \tfrac{1}{2}H_2(g) + 6H_2O(l) = Co^{++}(0.019\mathit{M}) + H^+ + 2NO_2^-\ (?) + 4NH_4OH(3.256\mathit{M})}$

$E_{298.1} = 0.1156$ (812)

$\mathbf{Co(NH_3)_6^{++} + 6H_2O(l) = Co^{++} + 6NH_4OH(aq)}$

$K_{298.1} = 1.25 \times 10^{-5}$ (812)

$[Co(NH_3)_6]^{+++}(0.077M)$ (hexamminecobaltic chloride) $+ \frac{1}{2}H_2(g) + 6H_2O(l) = Co^{++}(0.019M) + H^+ + 6NH_4OH(6M)$

$E_{298.1} = 0.1558$ (812)

$[Co(NH_3)_6]ClSO_4.3H_2O(s) = [Co(NH_3)_6]ClSO_4(s) + 3H_2O(g)$ (E)

$P_{298.1} = 0.0092 - 0.0116$ (77)

$[Co(NH_3)_6]_2(SO_4)_3.5H_2O(s) = [Co(NH_3)_6]_2(SO_4)_3.4H_2O(s) + H_2O(g)$ (E)

$P_{298.1} = 0.0178 - 0.01921$ (77)

$Co(H_2PO_2)_2.6NH_3(s) = (?) + xNH_3(g)$ (398) (E)

T	P	T	P
293.1	0.161	315.1	0.605
304.1	0.305	322.1	0.892
310.1	0.455	324.1	1.000 (extrap.)

$Co(HCO_2)_2.4NH_3(s) = (?) + xNH_3(g)$ (405) (E)

T	P	T	P
297.1	0.036	355.1	0.629
323.1	0.117	363.6	0.917
337.1	0.261	365.1	1.000 (extrap.)
347.1	0.379		

$Co(HCO_2)_2.6NH_3(s) = Co(HCO_2)_2.4NH_3(s) + 2NH_3(g)$ (405) (E)

T	P	T	P
258.1	0.129	287.1	0.670
273.1	0.296	293.1	0.888
279.1	0.424	294.6	1.000 (extrap.)
284.1	0.539		

$Co(CO)_4(g) = Co(s) + 4CO(g)$ (1013)

$Co(CH_3CO_2)_2.4(?)\ NH_3(s) = (?) + xNH_3(g)$ (405) (E)

T	P	T	P
287.1	0.088	323.1	0.714
300.1	0.183	327.1	0.914
312.1	0.384	328.6	1.000
318.1	0.554		

$[Co(C_2H_4)_3]Cl_3.3H_2O(s) = [Co(C_2H_4)_3]Cl_3(s) + 3H_2O(g)$ (E)

$P_{298.1} = 0.0059 - 0.0116$ (77)

$[Co(C_2H_4)_3]Br_3.3H_2O(s) = [Co(C_2H_4)_3]Br_3(s) + 3H_2O(g)$ (E)

$P_{298.1} = 0.0059 - 0.0092$ (77)

$[Co(C_2H_4)_3]I_3.3H_2O(s) = [Co(C_2H_4)_3]I_3(s) + 3H_2O(g)$ (E)

$P_{298.1} = 0.0013$ (77)

$Co(C_6H_5CO_2)_2.8NH_3(s) = Co(C_6H_5CO_2)_2.4NH_3(s) + 4NH_3(g)$ (383) (E)

T	P	T	P
278.6	0.161	304.6	0.939
285.6	0.303	305.6	1.000
295.6	0.547		

$Co(C_{10}H_7SO_3)_2.6NH_3(s) = (?) + xNH_3(g)$ (383) (E)

T	P	T	P
263.1	0.317	284.1	0.618
268.1	0.375	291.1	0.947
273.1	0.447	291.6	1.000
278.1	0.520		

$[Co(NH_3)_5Cl]IrCl_6.xH_2O$ (E)

Maximum H_2O = 12.52% or 4.13 moles; the dehydration proceeds continuously at 298.1°K (77)

$[Co(C_2H_4)_2(OH)(H_2O)]IrCl_6.xH_2O$ (E)

Maximum H_2O = 9.48% or 2.68 moles for *cis*-salt; = 8.0% or 2.26 moles for *trans*-salt. The dehydration proceeds continuously at 298.1°K (77)

$2CoO_2(s) = Co_2O_3(s) + \frac{1}{2}O_2(g)$ (519)

$[Co(NH_3)_4(H_2O)_2]_2(SO_4)_3.3H_2O(s) = [Co(NH_3)_4(H_2O)_2]_2(SO_4)_3(s) + 3H_2O(g)$ (E)

$P_{298.1} = 0.0022$ (77)

$[Co(NH_3)_5H_2O]_2(SO_4)_3.3H_2O(s) = [Co(NH_3)_5H_2O]_2(SO_4)_3.\frac{1}{2}H_2O(s) + 2\frac{1}{2}H_2O(g)$ (E)

$P_{298.1} = 0.0022$ (77)

$[Co(NH_3)_6]_2(SO_4)_3.4H_2O(s) = [Co(NH_3)_6]_2(SO_4)_3.H_2O(s) + 3H_2O(g)$ (E)

$P_{298.1} = 0.0057 - 0.0092$ (77)

$[Co(NH_3)_6]_2(SO_4)_3.5H_2O(s) = [Co(NH_3)_6]_2(SO_4)_3.4H_2O(s) + H_2O(g)$ (E)

$P_{298.1} = 0.0178 - 0.0192$ (77)

$[Co(NH_3)_4CO_3]_2SO_4.3H_2O(s) = [Co(NH_3)_4CO_3]_2SO_4(s) + 3H_2O(g)$ (E)

$P_{298.1} = 0.0099 - 0.0120$ (77)

$[Co(C_2O_4)(NO_2)_2(NH_3)_2]_2Zn.6NH_3(s) = [Co(C_2O_4)(NO_2)_2(NH_3)_2]_2Zn.4NH_3 + 2NH_3(g)$ (E)

P = 1.00 above room temperature (403)

$[Co(C_2O_4)(NO_2)_2(NH_3)_2]_2Zn.8NH_3(s) = [Co(C_2O_4)(NO_2)_2(NH_3)_2]_2Zn.6NH_3 + 2NH_3$ (E)

P = 1.00 between room temperature and 258.6°K (403)

$[Co(NH_3)_4(NO_2)_2]_2IrCl_6.3H_2O(s) = [Co(NH_3)_4(NO_2)_2]_2IrCl_6.1\frac{1}{2}H_2O(s) + 1\frac{1}{2}H_2O(g)$ (E)

$P_{298.1} = 0.0013 - 0.0022$ (77)

$[Co(C_2H_4)_2Cl_2]_2IrCl_6.H_2O(s) = [Co(C_2H_4)_2Cl_2]_2IrCl_6(s) + H_2O(g)$ (E)

$P_{298.1} = 0.0178 - 0.0232$ for *trans*-salt (77)

$[Co(C_2H_4)_2Cl_2]_2IrCl_6.4H_2O(s) = [Co(C_2H_4)_2Cl_2]_2IrCl_6(s) + 4H_2O(g)$ (E)

$P_{298.1} = 0.0013 - 0.0022$ for *cis*-salt (77)

$[Co(NH_3)_5H_2O]_2(IrCl_6)_3.xH_2O$ (E)

Maximum H_2O = 14.98%. The dehydration proceeds continuously at 298.1°K (77)

$[Co(NH_3)_6]_2(IrCl_6)_3.xH_2O$ (E)

Maximum H_2O = 21.39%; the dehydration proceeds continuously at 298.1°K (77)

$[Co(C_2H_4)_3]_2(IrCl_6)_3.xH_2O$ (E)

Maximum H_2O = 12.65% or 12.29 moles; the dehydration proceeds continuously at 298.1°K (77)

$Co_3O_4(s) = 3CoO(s) + \frac{1}{2}O_2(g)$ (438); *cf.* (226)

T	P	T	P
1 073	0.013	1 183	0.241
1 123	0.037	1 223	0.686
1 173	0.189	1 243	1.007

$Co_3O_4(s) + H_2(g) = 3CoO(s) + H_2O(g)$

$K_{723.1} = 34.4$ (1538); *cf.* (491)

$6Co_2O_3(s) = 4Co_3O_4 + O_2(g)$

$P_{645.1} = 1.00$ (226)

Ni, Nickel

$Ni(s) = Ni^{++} + 2E^-$ (1321.5)

T	$c_{(NiSO_4)}$	E
297.1	0.5	0.48 ± 0.005
368.0	0.5	0.44

$NiO(s) = Ni(s) + \frac{1}{2}O_2(g)$ (431); *cf.* (1397)

T	P	T	P
1 273	0.0026	1 473	0.0171
1 373	.0072	1 318	.0237

$NiO(s) + H_2(g) = Ni(s) + H_2O(g)$

$K_{723.1} = 15$ (1538); *cf.* (491, 1282)

$Ni^{++} + H_2O(l) = Ni(OH)^+ + H^+$ (800)

T	c	% Hydrolysis
358.6	0.0625	0.0084
373	.0156	.0194
373	.0625	.0142
373	.25	.0131

$NiCl_2(s) + H_2(g) = Ni(s) + 2HCl(g)$ (314); *cf.* (78)

T	K	T	K
583	0.0066	688	0.156
613	.024	718	1.000

$NiCl_2.2H_2O(s) = (?) + xH_2O(g)$ (E)

$P_{373.1} = 0.164$ (843, 844)

$NiCl_2.4H_2O(s) = NiCl_2.2H_2O(s) + 2H_2O(g)$ (331) (E)

T	P	T	P
288.1	0.0064*	320.79	0.0347
293.1	0.0068*	323.1	0.0392*
298.1	0.0078*	327.60	0.0532
298.10	0.0080	327.73	0.0536
303.1	0.0100*	328.1	0.0516*
305.41	0.0117	332.73	0.0741
308.1	0.0145*	333.1	0.0767*
311.30	0.0187	338.1	0.1030*
313.1	0.0214*	339.44	0.1106
318.1	0.0299*		

* Interpolated.

$NiCl_2.6H_2O(s) = NiCl_2.4H_2O(s) + 2H_2O(g)$ (331); *cf.* (844) (E)

T	P	T	P
288.1	0.0086*	304.1	0.0212
293.1	0.0100*	308.1	0.0275*
298.1	0.0138*	308.15	0.0275
303.1	0.0196*	308.35	0.0296†
303.8	0.0200		

* Interpolated. † Transition point.

$NiCl_2.NH_3(s) = NiCl_2(s) + NH_3(g)$ (95) (E)

T	P	T	P
538.1	0.026	612.1	0.293
557.6	0.050	628.1	0.462
584.1	0.132	646.1	0.934
595.1	0.209	648.1	1.000 (extrap.)
	$\Delta H = 21\ 460$		

$NiCl_2.2NH_3(s) = NiCl_2.NH_3(s) + NH_3(g)$ (95) (E)

T	P	T	P
488.1	0.014	569.1	0.6746
512.1	0.0809	578.1	0.876
533.1	0.175	584.1	0.934
555.1	0.353	586.1	1.000 (extrap.)
	$\Delta H = 19\ 000$ (102)		

$NiCl_2.6NH_3(s) = NiCl_2.2NH_3(s) + 4NH_3(g)$ (95, 102, 379) (E)

T	P	T	P
403.1*	0.159	430.6	0.503
411.1	0.211	437.1	0.638
415.1*	0.272	442.1	0.776
417.6	0.287	445.6	0.868
426.1	0.414	448.1*	0.934
428.1	0.458	450.1	1.020
	$\Delta H = 56\ 600$ (102)		

* From (379); all other values from (95).

$NiCl_2.6CH_3NH_2(s) = (?) + xCH_3NH_2(g)$ (393) (E)

T	P	T	P
356.6	0.0559	398.1	0.567
366.6	0.106	407.1	0.804
376.1	0.183	413.1	1.000 (interp.)
388.1	0.343	417.1	1.140
	$\Delta H = 14\ 870x$		

$NiCl_2.4C_2H_5NH_2(s) = (?) + xC_2H_5NH_2(g)$ (393) (E)

T	P	T	P
322.1	0.047	381.1	0.721
333.6	0.067	385.6	0.918
344.1	0.138	387.1	1.000 (interp.)
360.6	0.305	390.6	1.237
375.1	0.545	$\Delta H = 13\ 850x$	

$Ni(ClO_3)_2.6NH_3(s) = (?) + xNH_3(g)$ (379, 391) (E)

T	P	T	P
399.1	0.066	432.1	0.184
413.6	0.098	477.1	1.000 (extrap.)
	$\Delta H = 17\ 500x$		

$Ni(ClO_4)_2.6H_2O(s) = Ni(ClO_4)_2.4H_2O(s) + 2H_2O(g)$ (1290) (E)

T	P	T	P
357.1	0.0145	515.1	0.0579
385.1	0.0214	530.1	0.0666
410.1	0.0345*	535.1	0.0882
460.1	0.0482	540.1	0.1803
505.1†	0.0482	541.1	0.2355

* Transition point. † Decomposition begins at 513.1°K.

$Ni(ClO_4)_2.6NH_3(s) = (?) + xNH_3(g)$ (1290) (E)

T	P	T	P
380.1	0.0099	475.1	0.091
398.1	0.016	480.1	0.1337
450.1	0.024	484.1	0.1375
470.1	0.0676		

$NiBr_2(s) + H_2(g) = Ni(s) + 2HBr(g)$ (314)

$NiBr_2.NH_3(s) = NiBr_2(s) + NH_3(g)$ (97) (E)

T	P	T	P
549.3	0.0786	609.1	0.501
572.1	0.159	$\Delta H = 20\ 780$ (102)	

$NiBr_2.2NH_3(s) = NiBr_2.NH_3(s) + NH_3(g)$ (95, 97, 102) (E)

T	P	T	P
480.1	0.004	577.1	0.2217
491.1	0.011	582.1	0.251
509.1	0.018	583.1	0.262
523.1	0.034	584.6	0.275
535.1	0.049	588.1	0.350
546.1	0.089	591.1	0.374
549.3*	0.124	598.1	0.423
551.1	0.107	602.6	0.469
556.1	0.125	607.1	0.545
558.1†	0.132	613.1	0.707
562.1	0.134	620.1	0.787
568.1	0.1875	629.1	0.933
572.1	0.1928	$\Delta H = 20\ 400$†	

* From (97). † From (102); all other values from (95).

$NiBr_2.6NH_3(s) = NiBr_2.2NH_3(s) + 4NH_3(g)$ (95, 379) (E)

T	P	T	P
357.6	0.005	431.6	0.096
390.1	0.012	436.1	0.1335
407.6	0.034	443.6	0.193
423.1	0.059	447.1	0.2125
425.1	0.074	453.6	0.267

$NiBr_2.6NH_3$(s).—(*Continued*)

T	P	T	P
461.6*	0.509	476.1	0.787
465.6	0.463	479.1	0.932
467.1*	0.621	479.6*	0.913
471.1	0.641	480.6	0.942
472.1*	0.737	483.1	1.033
473.1	0.6995	486.1	1.089
	$\Delta H = 61\ 400$ (102)		

* From (379); all other values from (95).

$NiBr_2.6CH_3NH_2$(s) = (?) + xCH_3NH_2(g) (393) (E)

T	P	T	P
356.6	0.0559	398.1	0.567
366.6	0.1058	407.1	0.804
376.1	0.183	413.1	1.000 (interp.)
388.1	0.343	417.1	1.139
	$\Delta H = 14\ 870x$		

$NiBr_2.4C_2H_5NH_2$(s) = (?) + $xC_2H_5NH_2$(g) (393) (E)

T	P	T	P
376.6	0.058	423.1	0.708
386.6	0.145	432.6	1.020
397.6	0.251	437.1	1.251
411.6	0.418	$\Delta H = 15\ 970x$	

$NiBr_2.6C_2H_5NH_2$(s) = $NiBr_2.4C_2H_5NH_2$(s) + $2C_2H_5NH_2$(g) (393) (E)

T	P	T	P
293.1	0.045	345.6	0.680
310.6	0.107	352.1	0.908
315.1	0.142	354.1	1.000 (extrap.)
326.1	0.263	357.1	1.109
335.6	0.424	363.1	1.441
	$\Delta H = 25\ 120$		

$NiBr_2.4(CH_3)_2NH$(s) = (?) + $x(CH_3)_2NH$ (393) (E)

T	P	T	P
295.1	0.025	337.6	0.724
309.1	0.107	346.1	1.000 (interp.)
312.1	0.153	349.1	1.098
318.6	0.264	354.1	1.335
329.1	0.504	$\Delta H = 12\ 240x$	

$NiI_2.2NH_3$(s) = NiI_2(s) + $2NH_3$(g) (95, 102) (E)

T	P	T	P
452.1	0.0047	538.1*	0.132 (extrap.)
460.1	0.0053	549.6	0.167
479.1	0.0125	558.6	0.261
503.1	0.0499	575.1	0.4298
515.1	0.0572	581.6	0.459
519.6	0.0599	595.6	0.7572
526.1	0.0868	$\Delta H = 39\ 360$*	

* From (102); all other values from (95).

$NiI_2.6NH_3$(s) = $NiI_2.2NH_3$(s) + $4NH_3$(g) (95, 379) (E)

T	P	T	P
443.1	0.111	486.1	0.476
447.1*	0.112	491.1*	0.528
452.1*	0.147	493.1	0.618
455.1	0.164	498.6	0.743
468.1	0.257	507.1	0.947
478.1	0.362	508.6	1.000 (extrap.)
	$\Delta H = 63\ 760$ (102)		

* From (95); all other values from (379).

$NiI_2.6CH_3NH_2$(s) = (?) + xCH_3NH_2(g) (393) (E)

T	P	T	P
416.6	0.084	469.1	0.758
432.1	0.160	476.1	1.000 (interp.)
441.1	0.245	479.1	1.093
457.6	0.482	485.1	1.326
	$\Delta H = 17\ 370x$		

$NiI_2.4C_2H_5NH_2$(s) = (?) + $xC_2H_5NH_2$(g) (393) (E)

T	P	T	P
391.6	0.043	444.1	0.763
410.6	0.108	449.1	1.000 (interp.)
418.1	0.178	450.6	1.055
428.6	0.334	454.6	1.189
437.1	0.530	$\Delta H = 16\ 290x$	
	Decomposition product		
416.1	0.058	449.1	0.096
431.1	0.076	477.1	0.124

$NiI_2.6C_2H_5NH_2$(s) = $NiI_2.4C_2H_5NH_2$(s) + $2C_2H_5NH_2$(g) (393) (E)

T	P	T	P
330.1	0.063	368.6	0.734
345.1	0.203	373.6	0.918
357.1	0.430	375.1	1.000 (interp.)
363.6	0.599	380.6	1.275
	$\Delta H = 27\ 140$		

$NiI_2.4(CH_3)_2NH$(s) = (?) + $x(CH_3)_2NH$(g) (393) (E)

T	P	T	P
345.6	0.382	371.1	1.00 (interp.)
354.1	0.496	373.1	1.087
363.6	0.701	377.6	1.334
	$\Delta H = 13\ 220x$		

$NiI_2.6(CH_3)_2NH$(s) = $NiI_2.4(CH_3)_2NH$(s) + $2(CH_3)_2NH$(g) (393) (E)

T	P	T	P
273.6	0.054	292.6	0.707
276.1	0.132	296.6	0.924
282.6	0.324	298.1	1.000 (interp.)
285.1	0.408	299.1	1.074
	$\Delta H = 20\ 780$		

$NiI_2.2C_3H_7NH_2$(s) = (?) + $xC_3H_7NH_2$(g) (393) (E)

T	P*	T	P*
327.6	0.021	392.1	0.291
341.6	0.063	407.6	0.391
355.6	0.130	418.6	0.536
374.1	0.107	427.6	0.672

* The curve is abnormally flat. At higher pressures, the substance contains a different amount of $C_3H_7NH_2$.

NiI_2.1 or 1½ $(CH_3)_3N$(s) = (?) + $x(CH_3)_3N$(g) (393) (E)

T	P*	T	P*
316.1	0.036	368.1	0.220
333.1	0.068	383.1†	0.309
354.1	0.147	395.6	0.391

* The curve is abnormally flat. † The substance melts at 383.1°K.

$Ni(IO_3)_2.5NH_3$(s) = (?) + xNH_3(g) (391) (E)

T	P	T	P
326.1	0.236	350.1	0.882
338.1	0.480	352.6	1.191

$NiSO_4.H_2O$(s) = $NiSO_4$(s) + H_2O(g) (848) (E)

T	P	T	P
288.1	0.0138	333.1	0.211
293.1	0.0189	348.1	0.355

$NiSO_4.7H_2O(s) = NiSO_4.6H_2O(s) + H_2O(g)$ (E)

$P_{298.1} = 0.02722$ (1335); according to (848), the vapor pressure of the compound differs very little from that of the saturated solution

$NiSO_4.4NH_3(s) = NiSO_4.2NH_3(s) + 2NH_3(g)$ (381) (E)

T	P	T	P
409.1	0.116	443.6	0.724
424.6	0.188	448.1	0.943
436.6	0.461	451.6	1.000 (extrap.)
	$\Delta H = 32\ 880$		

$NiSO_4.6NH_3(s) = NiSO_4.4NH_3(s) + 2NH_3(g)$ (380); *cf.* (1238, 1532) (E)

T	P	T	P
373.6	0.224	404.6	0.846
384.1	0.338	407.1	0.989
395.6	0.580	$\Delta H = 29\ 340$	

Ephraim (380) found for a preparation after 1½ years the following pressures:

T	P	T	P
393.1	0.387	408.1	0.691
396.6	0.445	414.4	0.895
403.1	0.582	417.6	1.065

$NiS_2O_3.5NH_3(s) = (?) + xNH_3(g)$ (381) (E)

T	P	T	P
364.6	0.105	410.1	0.789
382.6	0.221	415.1	0.941
394.6	0.411	416.6	1.000 (extrap.)
405.6	0.671	$\Delta H = 15\ 000x$	

$NiS_2O_6.6NH_3(s) = (?) + xNH_3(g)$ (381) (E)

T	P	T	P
389.1	0.092	442.1	0.566
403.6	0.187	451.6	0.732
421.1	0.322	455.6	0.850
433.1	0.447	459.6	1.000 (extrap.)
	$\Delta H = 16\ 800x$		

$NiS_4O_6.6NH_3(s) = (?) + xNH_3(g)$ (381) (E)

T	P	T	P
349.1	0.079	399.1	0.776
369.6	0.208	403.1	0.888
378.6	0.333	404.6	0.920
389.6	0.579	406.6	1.000 (extrap.)
	$\Delta H = 14\ 700x$		

$NiSeO_4.6NH_3(s) = (?) + xNH_3(g)$ (E)

$P_{441.1} = 1.00$ (397)

$Ni(NO_2)_2.5NH_3(s) = Ni(NO_2)_2.4NH_3(s) + NH_3(g)$ (381)(E)

T	P	T	P
320.6	0.079	361.6	0.438
335.1	0.164	372.6	0.611
342.1	0.217	379.6	0.757
348.1	0.274	388.1	0.953
358.6	0.388	389.6	1.000 (extrap.)
	$\Delta H = 13\ 800$		

$Ni(NO_3)_2.6NH_3(s) = (?) + xNH_3(g)$ (381) (E)

T	P	T	P
388.1	0.087	420.6	0.254
395.6	0.118*	426.6	0.308*
408.6	0.163	432.6	0.366
413.1	0.217*	441.6	0.499*

$Ni(NO_3)_2.6NH_3(s)$.—(*Continued*)

T	P	T	P
444.6	0.542	458.6	0.833*
450.1	0.647*	464.1	0.996*
453.1	0.674	$\Delta H = 17\ 000x$	

* Substance contains somewhat less than 6 moles NH_3.

$(NH_4)_2Ni(SO_4)_2.6H_2O(s) = (NH_4)_2Ni(SO_4)_2.2H_2O(s) + 4H_2O(g)$ (265, 399) (E)

$\Delta H = 61\ 600$; $\log P = -0.511 + 2\ 437/T - 946\ 400/T^2$

T	P	T	P
306.6	0.0021	337.2	0.0245*
314.0	0.0045*	341.1	0.0320
316.3	0.0054	345.9	0.0420
321.3	0.0075*	393.1†	0.0537
326.8	0.0121	403.1†	0.0737

* Measured on cooling. † From (399); all other values from (265).

$Ni(H_2PO_2)_2.6NH_3(s) = (?) + xNH_3(g)$ (381) (E)

T	P	T	P
313.1	0.053	335.1	0.243
324.1	0.125	368.1	1.000 (extrap.)
330.6	0.192	$\Delta H = 13\ 300x$	

$Ni[I(As_2O_3)_2]_2.nNH_3(s) = (?) + xNH_3(g)$ (396) (E)

Moles NH_3	T at which $P = 1$	Moles NH_3	T at which $P = 1$
16.1	259.1	10.3	339.1
14.2	291.1	9.9	345.1
13.9	331.1	1.2	350.1

$Ni(HCO_2)_2.4NH_3(s) = (?) + xNH_3(g)$ (381) (E)

T	P	T	P
333.1	0.012	404.6	0.493
375.6	0.079	418.1	1.000 (extrap.)
391.6	0.192	$\Delta H = 15\ 100x$	

$Ni(HCO_2)_2.6NH_3(s) = Ni(HCO_2)_2.4NH_3(s) + 2NH_3(g)$ (381) (E)

T	P	T	P
273.1	0.164	293.1	0.479
283.1	0.287	297.1	0.592
289.1	0.403	304.1	0.816
292.1	0.467	308.1	0.980
	$\Delta H = 21\ 600$		

$Ni(CNS)_2.6NH_3(s) = Ni(CNS)_2.4NH_3(s) + 2NH_3(g)$ (381) (E)

T	P	T	P
318.1	0.132	351.1	0.761
330.1	0.263	357.1	0.974
340.1	0.441	357.6	1.000 (extrap.)
346.6	0.605	$\Delta H = 21\ 600$	

$Ni(CH_3CO_2)_2.nNH_3(s) = (?)^* + xNH_3(g)$ (381) (E)

T	P	T	P
Compound containing *ca.* 5½ moles NH_3			
273.1	0.158	302.6	0.868
282.1	0.305	304.1	0.921
294.6	0.600	306.1	0.968
299.6	0.757		
Compound containing *ca.* 5 moles NH_3			
293.1	0.026	346.6	0.579
304.1	0.079	350.1	0.687
316.1	0.164	352.6	0.803
326.6	0.245	353.1	0.838
336.1	0.349	357.1	1.026
339.6	0.428		

* Forms solid solution with NH_3.

$\mathrm{Ni(C_6H_5CO_2)_2}$ (Solid solution with *ca.* 7½ $\mathrm{NH_3}$) = $\mathrm{Ni(C_6H_5CO_2)_2.6NH_3(s) + xNH_3(g)}$ (383)

T	*P*	*T*	*P*
288.1	0.351	308.1	0.804
298.1	0.496	311.1	0.947
303.1	0.658	312.1	1.000

$\mathrm{Ni(C_6H_5CO_2)_2.8NH_3(s)}$ = (Solid solution with *ca.* 7½ $\mathrm{NH_3}$) + $\mathrm{xNH_3(g)}$ (383)

T	*P*	*T*	*P*
257.1	0.305	267.1	0.625
260.1	0.364	271.1	0.938
262.6	0.447	271.6	1.000

$\mathrm{Ni(C_6H_5SO_3)_2.6NH_3(s)}$ = (?) + $\mathrm{xNH_3(g)}$ (383) (E)

T	*P*	*T*	*P*
396.	0.318	417.6	0.953
413.6	0.750	418.6	1.000

Ni *o*-naphthoylbenzoate.$\mathrm{8NH_3(s)}$ = Ni *o*-naphthoylbenzoate.$\mathrm{6NH_3(s) + 2NH_3(g)}$ (383) (E)

T	*P**	*T*	*P**
266.1	0.192	281.6	0.487
268.1	0.237	285.1	0.632
272.1	0.309	289.1	0.855
277.1	0.408	291.1	0.968

* Since solid solutions result from the decomposition, the pressure of the pure octammine is somewhat higher than here found.

Ni dibromonaphthalene-2-sulfonate.$\mathrm{6NH_3(s)}$ = (?) + $\mathrm{xNH_3(g)}$ (E)

P = 1.00 at *ca.* 423°K (383)

Ni naphthalene-2-sulfonate.$\mathrm{8NH_3(s)}$ = Ni naphthalene-2-sulfonate.$\mathrm{6NH_3(s) + 2NH_3(g)}$ (383) (E)

T	*P*	*T*	*P*
278.1	0.303	298.1	0.980
286.1	0.493	299.1	1.019
292.1	0.704		

Ni dibromonaphthalene-2-sulfonate.$\mathrm{8NH_3(s)}$ = Solid soln. up to hexammine + $\mathrm{NH_3(g)}$ (E)

P = 1.00 at *ca.* 273.1°K (383)

Ni naphthalate.$\mathrm{6NH_3(s)}$ = Ni naphthalate.$\mathrm{4NH_3(s) + 2NH_3(g)}$ (E)

P = 1.00 below 273.1°K (383)

$\mathrm{Ni(NH_2C_6H_4SO_3)_2.8NH_3(s)}$ = (?) + $\mathrm{xNH_3(g)}$ (E)

Solid solutions result upon decomposition. The compound exerts a pressure of 1.00 atm. several degrees below 273.1°K (383)

$\mathrm{Ni[Co(NO_2)_4(NH_3)_2]_2.8NH_3(s)}$ = (?) + $\mathrm{xNH_3(g)}$ (E)

The pressure of $\mathrm{NH_3}$ above 273°K is considerable. On heating to 373.1°K, the compound still contains 6 moles of $\mathrm{NH_3}$ (396)

$\mathrm{Ni[Co(C_2O_4)(NO_2)_2(NH_3)_2]_2.8NH_3(s)}$ = (?) + $\mathrm{xNH_3(g)}$ (E)

The compound is stable at room temperature. At about 260°K it contains an additional 2 moles of $\mathrm{NH_3}$; at 253°K still 2 more moles of $\mathrm{NH_3}$ (396)

Cr, Chromium

$\mathrm{Cr(s) = Cr^{+++}}$; $E^0_{291.1} = -0.29$ (701)

$\mathrm{Cr^{+++} + H_2O(l) = Cr(OH)^{++} + H^+}$ (115); *cf.* (1155)

T	$c_{(\mathrm{CrCl_3})}$	$c_{(\mathrm{KCl})}$	K_c
290.1	0.0000625		0.99
290.1	.0000625	0.1	.41
291.0	.0000625		.88
291.0	.0000625	0.1	.44
273.1	.0003333		.27
273.1	.0003333	0.1	.156
290.1	.0003333		.83
290.1	.0003333	0.1	.48
290.1	0.0003333	0.2	0.30
291.1	.0003333		.88
291.1	.0003333	0.1	.51
291.1	.0003333	0.2	.32
290.1	.00100		.61
290.1	.00100	0.1	.45
292.1	.00100		.82
291.1	.0100		.79
291.1	.0100		.84

$\mathrm{HCrO_4^- = CrO_4^{--} + H^+}$

$K_{291.1} = 3.7 \times 10^{-7}$ (72)

$\mathrm{Cr(OH)^{++} + H_2O(l) = Cr(OH)_2^+ + H^+}$ (115)

T	$c_{(\mathrm{CrCl_3})}$	$c_{(\mathrm{KCl})}$	K_c
290.1	0.0000625	0.1	0.0062
273.1	.000333	0.1	.0025
290.1	.000333	0.1	.0060
290.1	.000333	0.2	.0065
290.1	.001000		.0059
290.1	.001000	0.1	.0096

$\mathrm{Cr(OH)_2^+ + H_2O(l) = Cr(OH)_3(s) + H^+}$ (115)

$\mathrm{Cr(OH)_3(s) + 3OH^- = CrO_3^{---} + 3H_2O(l)}$ (449.5, 1023.5, 1024.5)

$\mathrm{Cr(OH)_3(s) = Cr(OH)_2^+ + OH^-}$

$K = 1.5 \times 10^{-16}$ (701); *cf.* (115)

$\mathrm{CrCl_2.3NH_3(s)}$ = (?) (Decomposes without formation of solid soln.) + $\mathrm{xNH_3(g)}$ (395) (E)

T	*P*	*T*	*P*
317.1	0.059	365.1	0.813
332.6	0.127	367.6	0.901
345.1	0.261	368.1	0.961
359.1	0.570	Δ*H* = 13 100x	

$\mathrm{CrCl_2.6NH_3(s)}$ = (?) (Solid solution on decomposition) + $\mathrm{xNH_3(g)}$ (E)

$P_{313.1} = 1.00$; Δ*H* = 11 100x (395)

$\mathrm{[CrCl_2(H_2O)_4]^+}$ (green) + $\mathrm{3H_2O(l) = [Cr(H_2O)_6OH]^{++} + 2Cl^- + H^+}$

$K_{298.1} = 1.9 \times 10^{-4}$ (811); *cf.* (114, 115, 328, 809)

$\mathrm{CrBr_2.6NH_3(s)}$ = (?) + $\mathrm{xNH_3(g)}$ (E)

Dissociation temperature higher than that of $\mathrm{CrCl_2.6NH_3}$ (395)

$\mathrm{(NH_2OH)Cr(SO_4)_2.12H_2O(s)}$ = (?) + $\mathrm{xH_2O(g)}$ (1026) (E)

T	*P*	*T*	*P*
303.1	0.011	334.1	0.150
308.1	0.018	334.6	0.1503
312.1	0.026	338.1	0.184
318.1	0.047	342.1	0.228
328.1	0.103	345.1	0.263

$\mathrm{NH_4Cr(SO_4)_2.12H_2O(s)}$ = (?) + $\mathrm{xH_2O(g)}$ (399) (E)

T	*P*	*T*	*P*
323.1	0.053	353.1	0.321
333.6	0.105	359.1	0.429
345.1	0.213		

$\mathrm{Cr(NH_3)_6}$-salts; anions: Br, Cl, I, $\mathrm{NO_3}$ ($\mathrm{NO_3}$, Br), $\mathrm{SO_4}$, and $\mathrm{PO_4}$ (395) (E)

The results are not easy to interpret. The determination of the vapor pressure was made difficult through the slowness of pressure equilibrium, and through the tendency toward further decomposition

$\mathrm{Cr(H_2O)_6^{+++}}$ (hexaaquochromiate) + $\mathrm{CNS^- = Cr(H_2O)_5CNS^{++}}$ (thiocyanopentaaquochromiate) + $\mathrm{H_2O(l)}$

$K_{323.1} = 328$ (119); *cf.* (120)

$CH_3NH_2Cr(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (1025, 1026) (E)

T	P	T	P
308.1	0.007	341.1	0.155
315.1	0.018	342.1	0.161
323.1	0.042	345.6	0.203
333.1	0.095	348.1	0.236
336.6	0.121	351.6	0.286
340.1	0.147		

$[Cr(H_2O)_5CNS]^{++}$ (thiocyanopentaaquochromiate) + $CNS^- =$ $[Cr(H_2O)_4(CNS)_2]^+$ (dithiocyanotetraaquochromiate) + $H_2O(l)$

$K_{323.1} = 17.5$ (119); *cf.* (120)

$[Cr(H_2O)_4(CNS)_2]^+$ (dithiocyanotetraaquochromiate + $CNS^- =$ $[Cr(H_2O)_3(CNS)_3]$ (trithiocyanotriaaquochromiate) + $H_2O(l)$

$K_{323.1} = 4.56$ (119); *cf.* (120)

$CrO(s) + Cr_4C = 5Cr(s) + CO(g)$

$P_{1565} = 0.0058 - 0.0082$; $P_{1612} = 0.0121$ (1362, 1366)

$[Cr(H_2O)_3(CNS)_3]$ (trithiocyanotriaquochromiate + $CNS^- =$ $[Cr(H_2O)_2(CNS)_4]^-$ (tetrathiocyanodiaquochromiate) + $H_2O(l)$

$K_{323.1} = 1.93$ (119); *cf.* (120)

$[Cr(H_2O)_2(CNS)_4]^-$ (tetrathiocyanodiaquochromiate + $CNS^- =$ $[Cr(H_2O)(CNS)_5]^{--}$ (pentathiocyanoaquochromiate) + $H_2O(l)$

$K_{323.1} = 0.81$ (119); *cf.* (120)

$[Cr(H_2O)(CNS)_5]^{--}$ (pentathiocyanoaquochromiate) + $CNS^- =$ $[Cr(CNS)_6]^{---}$ (hexathiocyanochromiate) + $H_2O(l)$

$K_{323.1} = 0.41$ (119); *cf.* (120)

$PbCrO_4(s) = Pb^{++} + CrO_4^{--}$

$K_{291.1} = 1.77 \times 10^{-14}$ (72)

$PbSO_4(s) + CrO_4^{--} = PbCrO_4(s) + SO_4^{--}$ (1004); *cf.* (254)

T	K_c	T	K_c
291.1	0.000277	341.1	0.000440
311.1	.000365	371.6	.000505

$PbCrO_4(s) + CO_3^{--} = PbCO_3(s) + CrO_4^{--}$

$K_{291.1} =$ *ca.* 0.2 (36)

$2PbCO_3(s) + CrO_4^{--} + H_2O(l) = PbCrO_4.PbO(s) + 2HCO_3^-$

$K_{291.1} =$ *ca.* 1.95 (36)

$2PbCrO_4(s) + 2CO_3^{--} + H_2O(l) = PbCrO_4.PbO(s) + 2HCO_3^- + CrO_4^{--}$

$K_{291.1} =$ *ca.* 0.057 (36)

$TlCr(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (399) (E)

T	P	T	P
306.1	0.011	353.1	0.349
314.1	0.028	360.6	0.518
323.1	0.058	367.1	0.667
334.1	0.130	373.1	0.832
341.1	0.204	375.1	0.884
346.1	0.262		

$2AgIO_3(s) + CrO_4^{--} = Ag_2CrO_4(s) + 2IO_3^-$ (1167, 1168)

T	$c_{(KIO_3)}$	$c_{(K_2CrO_4)}$	$c_{(KNO_3)}$	μ_c	K_c
293.1	0.007	0.0865	0.02	0.2865	0.000567

Solid phases not identified; value approximate.

$Ag_2CrO_4(s) + 2H^+ = 2Ag^+ + H_2CrO_4(aq)$ (1345)

$c_{(Ag^+)} = 2c_{(\Sigma Cr)}$; $c_{(\Sigma Cr)} = c_{(H_2CrO_4)(aq)} + 2c_{(H_2Cr_2O_7)(aq)} + c_{(HCrO_4^-)} + 2c_{(Cr_2O_7^{--})}$; $c_{(HNO_3)(aq)} = c_{(HNO_3)(aq)}$ to which Ag_2CrO_4 was added.

$c_{(HNO_3)}$	$c_{(\Sigma Cr)}$	$c_{(HNO_3)}$	$c_{(\Sigma Cr)}$
0.01	0.0031575	0.025	0.004567
.015	.00373	.03	.005200
.02	.004178	.04	.005804

$Ag_2CrO_4(s) + 2H^+$.—(*Continued*)

$c_{(HNO_3)}$	$c_{(\Sigma Cr)}$	$c_{(HNO_3)}$	$c_{(\Sigma Cr)}$
0.05	0.006380	0.07	0.007333
.06	.006833	.075	.007425

$Ag_2CrO_4(s) + 4NH_4OH(aq) = 2Ag(NH_3)_2^+ + CrO_4^{--} + 4H_2O(l)$ (1345); *cf.* (142, 143)

$\frac{1}{3}\log(1/K)$ at 298.1°K $= -1.630 \pm 0.010$; $\Delta F^0_{298.1} = -6\ 674$

$c_{(Total\ NH_4OH)}$	$c_{(CrO_4^{--})}$	$c_{(Free\ NH_4OH)}$	$\frac{1}{3}\log(1/K'_c)$	$\mu_c^{1/2}$
0.01	0.002	0.00200	−1.7025	0.0775
.01	.002005	.00198	−1.7093	.0775
.02*	.004170	.00332	−1.7280	.1119
.04	.008585	.00566	−1.7328	.1605
.04	.008625	.00550	−1.7513	.1609
.08*	.01758	.00968	−1.8721	.2297

* Two experiments.

$NiCrO_4.6NH_3(s) = (?) + xNH_3(g)$ (E); $P_{408.1} = 1.00$ (397)

$Cr_2O_3(l) = Cr_2O_3(g)$ (157)

T	P	ΔH
2 500–3 000	1	63 000–77 000

$Cr_2O_3(s) = Cr_2O_3(g)$; $P_{2000} = 0.004$ (157)

$Cr_2O_7^{--} + H_2O(l) = 2CrO_4^{--} + 2H^+$; $K_{291.1} = 3.4 \times 10^{-13}$ (72)

$Cr_2O_7^{--} + H_2O(l) = 2HCrO_4^-$; $K_{291.1} = 2.5$ (72)

$HCr_2O_7^- = Cr_2O_7^{--} + H^+$; $K_{291.1} = 10^{-3}$ (72)

$Cr_2(SO_4)_3.nH_2O(s) = (?) + xH_2O(g)$ (1339) (E)

T	Pressures for n =				
	17.25	16.55	15.77	15.05	14.78
298.7	0.0263		0.0145	0.0146	
302.4	0.0321	0.0229	0.0184	0.0182	0.0168
307.1	0.0414	0.0318	0.0251	0.0242	0.0228
311.6	0.0514	0.0420	0.0328	0.0309	
313.5	0.0571		0.0364	0.0345	

$Cd[Cr(CNS)_4(NH_3)_2]_2.10NH_3(s) = (?) + xNH_3(g)$ (E)

$P = 1$ atm. at room temperature (396)

$Cd[Cr(CNS)_4(NH_3)_2]_2.$*ca.* $20NH_3(s) = (?) + xNH_3(g)$ (E)

$P = 1$ atm. at *ca.* 253.1°K (396)

$Ag_2Cr_2O_7(s) + H_2O(l) = 2Ag^+ + 2HCrO_4^-$ (1345)

$c_{(\Sigma H)}$	$c_{(\Sigma Cr)}$	$c_{(\Sigma Ag)}$
0.06	0.01110	0.01110
0.08	0.01110	0.01110
0.08	0.006623	0.016623

$2Ag_2CrO_4(s) + 2H^+ = Ag_2Cr_2O_7(s) + 2Ag^+ + H_2O(l)$ (1345)

$c_{(\Sigma H)}$	$c_{(\Sigma Cr)}$	$c_{(\Sigma Ag)}$
0.0	0.03220	0.005390
.01	.02506	.006131
.02	.02021	.007148
.04	.01359	.009524
.08	.00726	.01546
.10	.005647	.01901
.13	.004294	.02389
.14	.003498	.02563

$Ni[Cr(CNS)_4(NH_3)_2]_2.nNH_3(s) = (?) + xNH_3(g)$ (E)

n at 373.1°K = 4, at room temperature = 9; on evaporation of the solution, in liquid NH_3, n = 14 (396)

Mo, Molybdenum

$Mo(s) + 2H_2O(g) = MoO_2(s) + 2H_2(g)$ (277)

$Mo(CN)_8^{+++} = Mo(CN)_8^{++++} + E^-$ (302)

$NiMoO_4.6NH_3(s) = (?) + xNH_3(g)$ (E)

$P_{389.1} = 1.00$ (397)

W, Tungsten

$\frac{1}{2}WO_2(s) + H_2(g) = \frac{1}{2}W(s) + H_2O(g)$ (1538, 1542); *cf.* (277, 1206, 1541)

T	K	T	K
1 007 (1542)	0.45	1 214 (1542)	0.99
1 073 (1538)	.53	1 223 (1538)	1.00
1 101 (1542)	.65	1 273 (1538)	1.16
1 138 (1542)	.75	1 309 (1542)	1.29
1 173 (1538)	.82		

$WO_3(l) = WO_3(g)$

$P_{2000} = 1$; $\Delta H = 49\ 000$ (157); *cf.* (824)

$W(CN)_8^{+++} = W(CN)_8^{++++} + E^-$ (302)

$NiWO_4.6NH_3(s) = (?) + xNH_3(g)$ (E)

$P_{393.1} = 1.00$ (397)

$W_2O_5(s) + H_2(g) = 2WO_2(s) + H_2O(g)$

$K_{1073} = 5.0$ (1538); *cf.* (277)

$2WO_3(s) + H_2(g) = W_2O_5(s) + H_2O(g)$

$K_{1073} = 15$ (1538); *cf.* (1206)

U, Uranium

$U^{++++} + 2H_2O(l) = UO_2^{++} + 4H^+ + 2E^{-\prime}$ (924.5)

$UO_2SO_4.H_2O(s) = UO_2SO_4(s) + H_2O(g)$ (E)

$P_{298.1} = 0.0026$ (848); Lescoeur (848) also gives some data for a more highly hydrated salt

$UO_2(NO_3)_2.6H_2O(s) = (?) + xH_2O(g)$ (916); *cf.* (848) (E)

Maximum loss in weight at 298.1°K over $H_2SO_4(aq)$

P_{H_2O}	% Loss H_2O	P_{H_2O}	% Loss H_2O
0.02839	Deliquescent	0.00580	2.94
0.02579	Deliquescent	0.00230	2.99
0.02320	0.0	0.00074	3.97
0.01769	0.0	0.0003	4.01
0.01161	0.0	0.00	4.01

V, Vanadium

$VN(s) = V(s) + \frac{1}{2}N_2(g)$

$P_{1476} = >0.0003$ (1364); $P_{1544} = 0.0020$ (1365, 1366)

$(NH_4)V(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (399) (E)

T	P	T	P
323.1	0.049	353.1	0.309
333.1	0.097	363.1*	0.567
343.1	0.184		

* Decomposition begins.

$VO(s) + VC(s) = 2V(s) + CO(g)$

$P_{1613} = 0.0016 - 0.0022$; $P_{2100} = 1.00$ (extrap.); $\Delta H = 80\ 875$ (1366)

Ta, Tantalum

$TaN(s) = Ta(s) + \frac{1}{2}N_2(g)$

$P_{1443} = 0.0006$ (1364); $P_{1581} = 0.0013$ (1365, 1366)

$TaO(s) + TaC(s) = 2Ta(s) + CO(g)$

$P_{1548} = 0.00013$ (1366)

B, Boron

$HBO_2(aq) + AsO_2^- = HAsO_2(aq) + BO_2^-$ (32)

$T = 298.1$°K; $c_{(HNO_3)} = 0.8952$; $H_2BO_3(s)$ present; for the range $c_{(HAsO_2)} = 0.0626 - 0.2230$; $c_{(\Sigma As)} = 0.0856 - 0.2620$, $c_{(\Sigma Na)} = 0.3694 - 0.0522$, $c_{(AsO_2^-)} = 0.0084 - 0.0457$, $c_{(HAsO_4^-)} = 0.0019 - 0.0218$, K_c (average) $= 0.83$ with range $0.94 - 0.67$

$BO_2.H_2O_2^- = BO_2^- + H_2O_2(aq)$

$K_{273.1} = 0.024$ (983)

$H_3BO_3(aq) = H^+ + H_2BO_3^-$

$K_{291.1} = 5.7 \times 10^{-10}$ (982); $K_{298.1} = 8 \times 10^{-10}$ (1162); $= 5.78 \times 10^{-10}$ (177)

$BN(s) = B(s) + \frac{1}{2}N_2(g)$

$P_{1495} = 0.0116$ (1147.5, 1364, 1365, 1366)

$B_4O_7^{--} + 2CO_3^{--} + H_2O(l) = 2HCO_3^- + 4BO_2^-$ (982)

Al, Aluminium

$Al^{+++} + H_2O(l) = Al(OH)^{++} + H^+$ (800); *cf.* (1155)

$c_{(AlCl_3)}$	$c_{(NaCl)}$	% Hydrolysis	
		358.6°K	373.1°K
0.00065		34.09	47.68
0.0026		16.05	24.16
0.0104		6.57	9.92
0.00065	0.125	15.4	17.4
0.0026	0.0312	8.9	
0.0026	0.125	18.2	18.7
0.0104	0.0312	0.2	
0.0104	0.125	6.8	5.1
$c_{(Al(NO_3)_3)}$			
0.0026		15.36	23.98
$c_{(Al_2(SO_4)_3)}$*			
0.0001625 (0.000325)			48.22
0.0065 (0.0013)			23.17
0.0026 (0.0052)		8.39	9.64
0.0104 (0.0208)			5.115

* The concentrations given by (800) for $Al_2(SO_4)_3$ are probably twice the actual concentrations.

$Al(OH)_3(s) + OH^- = AlO_2^- + 2H_2O(l)$ (1359); *cf.* (1360)

T	$c_{(NaOH)}$	$c_{(AlO_2^-)}$
Room	0.6414	0.172

$Al(OH)_3(aq) = H^+ + AlO_3H_2^-$

$K > 10^{-10}$ (1360); *cf.* (328, 1550, 1551)

$AlCl_3.SO_2(s) = (?) + xSO_2(g)$ (392) (E)

T	P	T	P
273.1	0.026	311.6	0.138
282.6	0.053	335.1	0.211
293.6	0.086	373.1	0.329

$AlCl_3.\frac{1}{2}SO_2(s) = (?) + xSO_2(g)$ (E)

$P_{611.1} = 1.00$ (62)

$AlCl_3.\frac{1}{2}H_2S(s) = (?) + xH_2S(g)$ (E)

$P_{323.1} = 1.00$ calculated from heat of formation (62)

$AlCl_3.H_2S(s) = AlCl_3.\frac{1}{2}H_2S(s) + \frac{1}{2}H_2S(g)$ (E)

$P_{228.1} = 1$; calculated from heat of formation (62)

$AlCl_3.1\frac{1}{6}NH_3$* (E)	$AlCl_3.3\frac{1}{6}NH_3$* (E)	$AlCl_3.5\frac{1}{6}NH_3$* (E)
$P_{1041.1} = 1.00$ (62)	$P_{767.1} = 1.00$ (62)	$P_{607.1} = 1.00$ (62)

* Solid solutions of compound of this empirical molecular formula.

$AlCl_3.6NH_3(s) = (?) + xNH_3(g)$ (395) (E)

T	P	T	P
320.1	0.025	396.6	0.682
342.6	0.0513	401.1	0.908
370.6	0.184	402.6	1.000 (extrap.)

$\Delta H = 14\ 500x$

$AlCl_3.6\frac{1}{6}NH_3(s) = (?)$ (Solid solution) $+ xNH_3(g)$ (E)

$P_{359.5} = 1.000$ (62); Ephraim and Millman (395) find for $AlCl_3.6NH_3$ saturated with NH_3 at room temperatures, a pressure of 0.164 atm. at $T = 322.1$

$AlCl_3.9\frac{1}{6}NH_3(s) = (?)$ (Solid solution) $+ xNH_3(g)$ (62) (E)

T	P	T	P
236.1	0.249	262.4	1.287
250.8	0.633	273.1	2.355
258.5	1.000 (interp.)		

$AlCl_3.6C_2H_2(s) = (?) + xC_2H_2(g)$ (E)

$P_{213.1} = 1.00$ calculated from heat of formation (62)

$AlBr_3.SO_2(s) = (?) + xSO_2(g)$ (392) (E)

T	P	T	P
289.1	0.014	348.1	0.283
325.6	0.161	360.6	0.384

$AlBr_3.6NH_3{}^*(s) = (?) + xNH_3(g)$ (395) (E)

T	P	T	P
421.1	0.113	484.1	0.579
444.6	0.155	501.1	1.000 (interp.)
469.6	0.321	502.1	1.037
	$\Delta H = 18\,400x$		

* The hexammine absorbs 2.5 % more NH_3 at room temperature. It then shows a pressure of 0.066 atm. at $T = 273.1$°K.

$AlI_3.SO_2(s) = (?) + xSO_2(g)$ (392) (E)

T	P	T	P
290.6	0.013	361.1	0.279
313.1	0.071	363.1	0.349
327.1	0.129		

$AlI_3.6\tfrac{1}{6}NH_3(s) = (?) + xNH_3(g)$ (395) (E)

T	P	T	P
292.6	0.039	352.6	1.00 (interp.)
325.6	0.212	353.6	1.054
	$\Delta H = 12\,500x$		

$AlN(s) = Al(l) + \tfrac{1}{2}N_2(g)$ (417)

$(NH_2OH)Al(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (1026) (E)

T	P	T	P
300.1	0.008	333.1	0.145
305.1	0.013	335.1	0.1455
308.1	0.016	336.1	0.149
313.1	0.028	338.1	0.168
318.1	0.045	343.1	0.226
328.1	0.101	348.1	0.297

$NH_4Al(SO_4)_2.3H_2O(s) = NH_4Al(SO_4)_2.H_2O(s) + 2H_2O(g)$ (E)

$P_{373.1} = 0.099$ (851); *cf.* (1033)

$NH_4Al(SO_4)_2.12H_2O(s) = NH_4Al(SO_4)_2.3H_2O(s) + 9H_2O(g)$ (399, 851); *cf.* (1033) (E)

T	P	T	P
323.1	0.028	351.9*	0.193
333.1*	0.061	352.1	0.212
333.1	0.064	357.1	0.288
342.4*	0.108	361.5*	0.421
343.1	0.114		

* From (851); all other values from (399).

$CH_3NH_2Al(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (1026) (E)

T	P	T	P
313.1	0.0164	343.1	0.166
323.1	0.0401	345.1	0.184
328.1	0.061	348.6	0.216
333.1	0.088		

$Al(CN)_3.6NH_3(s) = (?) + xNH_3(g)$ (E); $P_{240.1} = 0.013$ (82)

$Al(CN)_3.9NH_3(s) = Al(CN)_3.6NH_3(s) + 3NH_3(g)$ (E)

$P_{240.1} = 0.132$ (82)

$Al(CN)_3.14(?)NH_3(s) = Al(CN)_3.9NH_3(s) + 5(?)NH_3(g)$ (E)

$P_{240.1} = 0.605$ (82)

$TlAl(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (399) (E)

T	P	T	P
324.1	0.030	353.1	0.241
333.1	0.066	359.1	0.368
343.1	0.130	362.1	0.476

$Al_2O_3(s) = 2Al(g) + \tfrac{3}{2}O_2(g)$

$P_{2000} = <10^{-50}$ (157)

$Al_2O_3(s) = Al_2O_3(g)$

$P_{2000} = 0.035$ (157); $P_{2500} = 1.000$ (1279)

$Al_2O_3(s) + 3C$ (graph.) $+ N_2(g) = 2AlN(s) + 3CO(g)$ (444)

Sc, Scandium

$Sc_2(SO_4)_3(s) = (?) + SO_2(g) + O_2(g)$ (1539)

T	P	T	P
1 073	0.039	1 173	0.375
1 093	0.063	1 213	0.820
1 113	0.101	At 1173°K, $P_{SO_3} = 0.014$	
1 133	0.164		

Y, Yttrium

$Y(NO_3)_3.6H_2O(s) = (?) + xH_2O(g)$ (916) (E)

Maximum loss in weight at 298.1°K over $H_2SO_4(aq)$

P_{H_2O}	Loss H_2O, Moles	P_{H_2O}	Loss H_2O, Moles
0.02839	Deliquescent	0.00580	1.02
0.02579	Deliquescent	0.00230	1.03
0.02320	Deliquescent	0.00074	3.01
0.01769	Deliquescent	0.0003	3.01
0.01161	0.00	0.00	3.03

$Y_2(SO_4)_3(s) = (?) + SO_2(g) + O_2(g)$ (1539)

T	P	T	P
1 113	0.018	1 253	0.325
1 133	.029	1 273	.449
1 173	.072	1 293	.618
1 213	.162	At 1173°K, $P_{SO_3} = 0.004$	

$Y_2(C_2O_4)_3.9H_2O(s) = (?) + xH_2O(g)$ (916) (E)

Maximum loss in weight at 298.1°K over $H_2SO_4(aq)$

P_{H_2O}	Loss H_2O, Moles	P_{H_2O}	Loss H_2O, Moles
0.02839	0.0	0.00580	0.50
0.02579	0.06	0.00230	3.96
0.02320	0.16	0.00074	6.21
0.01769	0.26	0.0003	6.86
0.01161	0.34	0.00	7.05

La, Lanthanum

$La(NO_3)_3.6H_2O(s) = (?) + xH_2O(g)$ (916) (E)

Over $H_2SO_4(aq)$

P_{H_2O}	Loss H_2O, Moles	P_{H_2O}	Loss H_2O, Moles
0.02839	Deliquescent	0.00580	0.00
0.02579	Deliquescent	0.00230	2.01
0.02319	Deliquescent	0.00074	1.98
0.01769	0.0	0.0003	4.92
0.0116	0.0	0.000	4.98

$La_2(SO_4)_3(s) = (?) + SO_2(g) + O_2(g)$ (1539)

T	P	T	P
1 113	0.013	1 253	0.258
1 133	.021	1 273	.355
1 173	.054	1 293	.487
1 213	.130	At 1173°K, $P_{SO_3} = 0.0026$	

$La_2(SO_4)_3.6H_2O(s) = (?) + xH_2O(g)$ (916) (E)
Over $H_2SO_4(aq)$

p_{H_2O}	Loss H_2O, Moles	p_{H_2O}	Loss H_2O, Moles
0.02839	0.0	0.00580	0.0
0.02579	0.0	0.00230	0.0
0.02319	0.0	0.00074	3.04
0.01769	0.0	0.0003	5.96
0.0116	0.0	0.000	6.03

$La_2(C_2O_4)_3.9H_2O(s) = (?) + xH_2O(g)$ (916) (E)
Over $H_2SO_4(aq)$

p_{H_2O}	Loss H_2O, Moles	p_{H_2O}	Loss H_2O, Moles
0.02839	0.02	0.00580	0.41
0.02579	0.08	0.00230	0.57
0.02319	0.12	0.00074	3.93
0.01769	0.18	0.0003	6.89
0.0116	0.26	0.000	6.95

Ce, Cerium

$CeCl_3.2NH_3(s) = CeCl_3(s) + 2NH_3(g)$ (55) (E)

T	P	T	P
363.1	0.545	378.1	1.594
373.1	1.089		

$CeCl_3.4NH_3(s) = CeCl_3.2NH_3(s) + 2NH_3(g)$ (55) (E)

T	P	T	P
323.1	0.295	343.6	1.209
333.1	0.645	348.1	1.695
338.1	0.858		

$CeCl_3.8NH_3(s) = CeCl_3.4NH_3(s) + 4NH_3(g)$ (E)

T	P	T	P
273.1	0.345	300.1	1.421
282.6	0.654	303.1	1.718
292.1	1.053		

$CeCl_3.12NH_3(s) = CeCl_3.8NH_3(s) + 4NH_3(g)$ (55) (E)

T	P	T	P
243.1	0.432	262.1	1.160
255.1	0.836	273.1	2.068
258.1	0.934		

$CeCl_3.20NH_3(s) = CeCl_3.12NH_3(s) + 8NH_3(g)$ (55) (E)

T	P	T	P
204.1	0.087	247.1	1.263
233.1	0.734	256.6	2.006
238.1	0.892	273.1	4.142

$CeN(s) = Ce(s) + \frac{1}{2}N_2(g)$ (902)

$2CeN(s) + 3H_2(g) = 2CeH_3(s) + N_2(g)$ (1041)

$Ce(NO_3)_3.6H_2O(s) = (?) + xH_2O(g)$ (916) (E)
Over $H_2SO_4(aq)$

p_{H_2O}	Loss H_2O, Moles	p_{H_2O}	Loss H_2O, Moles
0.01161	0	0.00074	2.01
0.00580	0	0.00026	4.89
0.00230	2.01	0.000	5.05

$Ce_2(SO_4)_3(s) = 2CeO_2(s) + O_2(g) + 3SO_2(g)$ (1540)

T	P	P_{SO_3}
973	0.013	
1 053	.066	
1 133	.339	0.030
1 173	.671	.062
1 193	.982	

$Ce_2(SO_4)_3.8H_2O(s) = (?) + xH_2O(g)$ (E)
Over $H_2SO_4(aq)$

p_{H_2O}	Loss H_2O, Moles	p_{H_2O}	Loss H_2O, Moles
0.01161	2.99	0.00074	4.00
0.00580	2.99	0.00026	5.98
0.00230	3.91	0.0000	5.98

$Ce_2(C_2O_4)_3.10H_2O(s) = (?) + xH_2O(g)$ (916) (E)
Over $H_2SO_4(aq)$

p_{H_2O}	Loss H_2O, Moles	p_{H_2O}	Loss H_2O, Moles
0.02838	0.06	0.00580	0.91
0.02580	0.15	0.00230	1.20
0.02319	0.27	0.00074	4.35
0.01769	0.36	0.00026	9.29
0.01161	0.60	0.0000	9.29

Pr, Praseodymium

$Pr_2(SO_4)_3(s) = (?) + SO_2(g) + O_2(g)$ (1539)

T	P	T	P
1 093	0.024	1 253	0.539
1 113	.037	1 273	.742
1 133	.057	1 293	1.026
1 173	.118	At 1173°K, $P_{SO_3} = 0.0072$	
1 213	.270		

Nd, Neodymium

$Nd_2(SO_4)_3(s) = (?) + SO_2(g) + O_2(g)$ (1539)

T	P	T	P
1 073	0.018	1 213	0.313
1 093	.028	1 253	.618
1 113	.045	1 273	.855
1 133	.067	At 1173°K, $P_{SO_3} = 0.008$	
1 173	.145		

Sa, Samarium

$Sa_2(SO_4)_3(s) = (?) + SO_2(g) + O_2(g)$ (1539)

T	P	T	P
1 073	0.025	1 173	0.168
1 093	.038	1 213	.401
1 113	.058	1 253	.816
1 133	.076	At 1173°K, $P_{SO_3} = 0.011$	

Gd, Gadolinium

$Gd_2(SO_4)_3(s) = (?) + SO_2(g) + O_2(g)$ (1539)

T	P	T	P
1 073	0.021	1 213	0.355
1 093	.033	1 253	.705
1 113	.051	1 273	.971
1 133	.076	At 1173°K, $P_{SO_3} = 0.009$	
1 173	.168		

Er, Erbium

$Er_2(SO_4)_3(s) = (?) + SO_2(g) + O_2(g)$ (1539)

T	P	T	P
1 113	0.030	1 253	0.454
1 133	.046	1 273	.632
1 173	.107	1 293	.875
1 213	.233	At 1273°K, $P_{SO_3} = 0.007$	

$Er_2(C_2O_4)_3.12H_2O(s) = (?) + xH_2O(g)$ (916) (E)

Maximum loss in weight at 298.1°K over $H_2SO_4(aq)$ of following strengths:

% H_2SO_4	Loss H_2O, Moles*	% H_2SO_4	Loss H_2O, Moles*
10	0.0	60	0.65
20	0.11	70	4.43
30	0.28	80	6.52
40	0.44	90	6.59
50	0.56	97	7.11

* The loss of water takes place continuously.

Yb, Ytterbium

$Yb_2(SO_4)_3(s) = (?) + SO_2(g) + O_2(g)$ (1539)

T	P	T	P
1 113	0.025	1 253	0.395
1 133	.039	1 273	.553
1 173	.091	1 293	.743
1 213	.197	At 1273°K, $P_{SO_3} = 0.005$	

Lu, Lutecium

$Lu_2(SO_4)_3(s) = (?) + SO_2(g) + O_2(g)$ (1539)

T	P	T	P
1 113	0.022	1 253	0.361
1 133	.034	1 273	.503
1 173	.082	1 293	.684
1 213	.179	At 1273°K, $P_{SO_3} = 0.0046$	

Be, Beryllium

$Be^{++} + H_2O(l) = BeOH^+ + H^+$; $K = 0.000232$ (1551)

$Be(OH)_2(s) = BeOH^+ + OH^-$; $K = 5.2 \times 10^{-11}$ (1551)

$BeO_2^{--} + H_2O(l) = Be(OH)_2(s) + 2OH^-$; $K = 0.00121$ (1551)

$BeSO_4(s) = (?) + SO_3(g)$

$\log P_{SO_3} = -14\ 907/T - 14.10 \log T + 55.09$ (951)

$BeSO_4.2H_2O^*(s) = (?) + xH_2O(g)$ (795) (E)

Moles H_2O content	T	P	Moles H_2O content	T	P
1.87	438.1	0.0149	0.41	534.1	0.0237
1.76	454.1	0.0112	0.14	555.1	0.0238
1.51	473.1	0.0220	0.09	573.1	0.00062
1.18	484.1	0.0255	0.06	583.1	0.00062
0.88	501.1	0.0254	0.04	628.1	0.0253
0.66	508.1	0.0193	0.02	663.1	0.0237

* ΔH for decomposition to monohydrate = 21 220; ΔH for decomposition of monohydrate to anhydrous substance = 23 430.

$BeSO_4.4H_2O(s) = BeSO_4.2H_2O(s) + 2H_2O(g)$ (E)

$P_{387.1} = 0.024$; $\Delta H = 34\ 500$ (795)

Mg, Magnesium

$Mg(s) = Mg^{++} + 2E^-$ (1382)

$MgO(l) = Mg(g) + \frac{1}{2}O_2(g)$

At 3000°K, $P_{O_2} = 0.3$ (157)

$MgO(s)$; $C_p = 9.6$ (885, 1108)

$MgO(s) = Mg(g) + \frac{1}{2}O_2(g)$

At 2000°K, $P_{O_2} = 0.000008$ (157)

$MgO(s) + C\ (graph.) = Mg(g) + CO(g)$ (1277)

$MgO(s) = MgO(g)$

$P_{2000} = 0.0004$ (157)

$Mg^{++} + H_2O(l) = MgOH^+ + H^+$

In $MgCl_2$ at 373.1°K, $c_{(MgCl_2)} = 0.0625$; % hydrolysis = 0.00266 (800)

$Mg(OH)_2 + 2NH_4^+ = Mg^{++} + 2NH_4OH(aq)$ (612, 613, 1454)

$Mg(OH)_2(s) = MgO(s) + H_2O(g)$ (711) (E)

T	P	T	P
308.1	0.010	358.1	0.172
309.1	0.013	359.1	0.196*
317.1	0.0229*	360.1	0.211
323.1	0.034	367.1	0.272
326.1	0.0414*	373.1	0.308*
335.1	0.064	375.1	0.321
336.1	0.072*	391.1	0.467*
339.1	0.088	395.1	0.521
347.1	0.121	420.1	0.692*
352.1	0.149	431.1	0.770
353.1	0.164	444.1	0.836

* Interpolated.

$MgCl_2(s)$; $C_p = 18.7$ (885)

$MgCl_2(s) + \frac{1}{2}O_2(g) = MgO(s) + Cl_2(g)$ (885)

$\Delta F^0 = 8\ 820 + 4.95T \ln T - 0.00025T^2 - 44.95T$ (range 823 to 987°K); $\Delta F^0_{298.1} = 3\ 810$ (885); *cf.* (545, 547, 634, 1010)

$MgCl_2(s) + H_2O(g) = MgO(s) + 2HCl(g)$

$\Delta F^0 = 22\ 480 + 4.91T \ln T - 0.00195T^2 + 0.00000037T^3 - 59.10T$ (range 803 to 973°K); $\Delta F^0_{298.1} = 13\ 040$ (885) *from* (1010)

$MgCl_2.1\frac{1}{2}H_2O(s) = (?) + xH_2O(g)$ (E)

$P_{413.1} = 0.191$ (847)

$MgCl_2.4H_2O(s) = (?) + xH_2O(g)$ (E)

$P_{373.1} = 0.039$ (847)

$MgCl_2.6H_2O(s) = MgCl_2.4H_2O(s) + 2H_2O(g)$ (331, 847) (E)

T	P	T	P
304.7	0.0021	361.95	0.0546
310.6*	0.003	370.06	0.0830
315.20	0.0036	373.1*	0.109
331.41	0.0103	377.8	0.1296
337.20	0.0149	381.3	0.1536
337.6*	0.013	383.1*	0.163
341.37	0.0174	386.2	0.1922
342.48	0.0192	388.7	0.2177
347.37	0.0280	393.1*	0.271
349.63	0.0288	403.1*	0.362
350.6*	0.030		

* From (847); all other values from (331).

$MgCl_2.NH_3(s) = MgCl_2(s) + NH_3(g)$ (103.5) (E)

T	P	T	P
502.1	0.008	572.1	0.124
549.6	0.054	$\Delta H = 20\ 800$	

$MgCl_2.2NH_3(s) = MgCl_2.NH_3(s) + NH_3(g)$ (103.5) (E)

T	P	T	P
454.6	0.024	502.1	0.205
488.1	0.107	$\Delta H = 17\ 900$	

$MgCl_2.6NH_3$ and $MgCl_2.2NH_3$ (saturated mixed crystals) $= (?) + xNH_3(g)$ (E)

$P_{367.1} = 0.132$; $\Delta H = 13\ 300x$ (108)

$MgBr_2.H_2O(s) = MgBr_2(s) + H_2O(g)$ (847) (E)

T	P	T	P
393.1	0.033	423.1	0.106
403.1	0.039	433.1	0.192
413.1	0.067	438.1	0.270

$MgBr_2.6H_2O(s) = MgBr_2.H_2O(s) + 5H_2O(g)$ (847) (E)

T	P	T	P
293.1	0.0139	333.1	0.163

$MgBr_2.NH_3$(s) = $MgBr_2$(s) + NH_3(g) (103.5) (E)

T	P	T	P
503.1	0.0041	573.1	0.049
550.1	0.0229	ΔH = 21 700	

$MgBr_2.2NH_3$(s) = $MgBr_2.NH_3$(s) + NH_3(g) (103.5) (E)

T	P	T	P
488.1	0.011	550.6	0.107
503.6	0.0176	573.1	0.195
	ΔH = 20 100		

$MgBr_2.6NH_3$ and $MgBr_2.2NH_3$ (saturated mixed crystals) = (?) + xNH_3(g) (E)

$P_{420\cdot1}$ = 0.132; ΔH = 15 200x (103.5)

$MgI_2.2NH_3$*(s) = MgI_2(s) + $2NH_3$(g) (103.5) (E)

T	P	T	P
488.1	0.00087	503.1	0.0013
	ΔH = 45 400		

* Isambert (666) and Ephraim (379) give data for various magnesium halide ammoniates.

$MgI_2.6NH_3$ and $MgI_2.2NH_3$ (saturated mixed crystals) = (?) + xNH_3(g) (E)

$P_{475\cdot1}$ = 0.132; ΔH = 17 200x (103.5)

$MgSO_4$(s) = (?) + SO_2(g) + O_2(g) (636, 951)

$MgSO_4.H_2O$(s) = $MgSO_4$(s) + H_2O(g) (E)

$P_{298\cdot1}$ = 0.0013 (430)

$MgSO_4.H_2O$(s) = $MgSO_4$. (?) H_2O(s) + xH_2O(g) (E)

$P_{303\cdot85}$ = 0.000 (148)

$MgSO_4.2H_2O$(s) = $MgSO_4.H_2O$(s) + H_2O(g) (E)

$P_{303\cdot85}$ = 0.00359 (148)

$MgSO_4.4H_2O$(s) = $MgSO_4.2H_2O$(s) + $2H_2O$(g) (E)

$P_{303\cdot85}$ = 0.00945 (148)

$MgSO_4.5H_2O$(s) = $MgSO_4.H_2O$(s) + $4H_2O$(g) (E)

$P_{298\cdot1}$ = 0.0064 (430)

$MgSO_4.5H_2O$(s) = $MgSO_4.4H_2O$(s) + H_2O(g) (148, 430) (E)

T (430)	P	T (148)	P
298.1	0.0116	303.85	0.01646

$MgSO_4.6H_2O$(s) = $MgSO_4.5H_2O$(s) + H_2O(g) (148, 430); *cf.* (843, 844, 1032) (E)

T (430)	P	T (148)	P
298.1	0.0129	303.85	0.02094

$MgSO_4.7H_2O$(s) = $MgSO_4.6H_2O$(s) + H_2O(g) (257, 458) (E)

T	P	T*	P
288.05	0.00641	305.50	0.0300
293.15	0.00999	309.75	0.0413
298.10*	0.0167	313.29	0.0534
298.85	0.01601	318.17	0.0753
303.85	0.02391	318.31	0.076
304.15	0.02459		

* From (257); all other values from (458).

Accurate single values; *cf.* (331, 843, 986, 1032, 1325)

T	P	T	P
293.1 (641)	0.012	303.85 (148)	0.02488
298.1 (430)	0.0155	303.85 (295)	0.02496
298.1 (1335)	0.0164	307.3 (895)	0.032

$MgSO_4.12H_2O$(s) = $MgSO_4.7H_2O$(s) + $5H_2O$(g) (843, 844) (E)

T	P	T	P
283.1	0.0100	293.1	0.0192

$MgSO_4.7H_2O$ and $CuSO_4.5H_2O$ (mixed crystals) = (?) + xH_2O(g) (691) (E)

T = 293.1 ± 0.02°K

Mole % $MgSO_4$	P	Mole % $MgSO_4$	P
Rhombic $7H_2O$		Monoclinic $7H_2O$	
100.0	0.011	68.0	0.0199
97.9	0.0104	59.9	0.0197
	Triclinic $5H_2O$		
15.2	0.0062	4.5	0.0068
7.6	0.0063	0.0	0.0076

$MgSO_4.7H_2O$ and $ZnSO_4.7H_2O$ (mixed crystals) = (?) + xH_2O(g) (641) (E)

T = 293.1 ± 0.02°K

Mole % $MgSO_4$	P	Mole % $MgSO_4$	P
100.0	0.0105	48.8	0.0129
90.1	0.0103	44.3	0.0126
81.6	0.0101	31.7	0.0124
72.0	0.0108	23.6	0.0125
66.0	0.0114	11.2	0.0130
63.0	0.0109	0.0	0.0138
54.5	0.0114		

$MgSO_4.7H_2O$ and $FeSO_4.7H_2O$ (mixed crystals) = (?) + xH_2O(g) (E)

The vapor pressure of the monoclinic mixed crystals is lower, that of the rhombic higher than that of the components. At 317.11°K, the vapor pressure of the mixed crystals is equal to that of the components (1239)

$(NH_4)_2Mg(SO_4)_2.6H_2O$(s) = $(NH_4)_2Mg(SO_4)_2.4H_2O$(s) + $2H_2O$(g) (265); *cf.* (399) (E)

$\log P = 2.502 + 485.1/T - 563\,500/T^2$; ΔH = 27 400

T	P	T	P
315.9	0.0239	316.8	0.0259*
325.2	0.0463	309.4	0.0151*
334.3	0.0805	301.5	0.0083*
341.3	0.1221		

* Measured on cooling.

$MgCO_3$(s) = MgO(s) + CO_2(g) (946); *cf.* (180, 270, 271, 453, 525, 595, 597.5, 948) (E)

T	P	T	P
673.1	0.0001	813.1	0.983
673.1	0.0037*	813.1	0.949*
723.1	0.0089	843.1	1.763
723.1	0.0076*	843.1	3.67*
763.1	0.0776	873.1	13.87*
763.1	0.0825*	973.1	473.4*
	ΔH = 60 863		

* Calculated by means of equation:

$$\log k_{P_1} - \log k_{P_2} = \Delta H(T_1 - T_2)/4.571(T_1 \cdot T_2)$$

$MgCO_3.3H_2O$ (nesquehonite) + $CO_2(g)$ = Mg^{++} + $2HCO_3^-$ + $2H_2O(l)$ (1191) *from* (247, 374, 376, 563, 564, 565, 1455, 1515)

T	$c(Mg^{++})$	$c(HCO_3^-)$	$c(NaCl)$	P_{CO_2}	f_{CO_2}	$\mu_c^{1/2}$	log $(1/K_c^{1/3})$	Lit.
288.1	0.0224	0.0278		0.00039	0.000386	0.276	0.4509	(1455)
288.1	.0233	.0296		.00145	.00144	.279	.6164	(1455)
288.1	.0244	.0304		1.00210	.00208	.288	.6550	(1455)
363.1	.028	.056		1.007	1.000	.290	1.3522	(376*)
288.1	.0270	.0360		0.00330	0.00327	.300	0.6568	(1455)
288.1	.0324	.0466		.00605	.00599	.309	.6433	(1455)
288.1	.0356	.0500		.00618	.00612	.342	.6125	(1455)
288.1	.0505	.0814		.0108	.0107	.401	.5016	(1455)
355.1	.058	.116		1.007	1.000	.417	1.0359	(376*)
288.1	.0615	.1042		0.0136	0.0135	.440	0.4352	(1455)
288.1	.0830	.1656		.0444	.0440	.499	.4288	(1455)
288.1	.0830	.1656		.0547	.0542	.499	.4589	(1455)
288.1	.0830	.1656		.1885	.1867	.499	.6380	(1455)
288.1	.0830	.1470		.0154	.0153	.508	.3093	(1455)
343.1	.096	.192		1.007	1.000	.537	.8170	(376*)
323.1	.113	.226		1.00	0.99	.582	.7447	(374*)
335.1	.123	.246		1.007	1.000	.607	.7094	(376*)
313.1	.140	.280		1.00	0.99	.648	.6517	(374*)
319.1	.186	.372		1.007	1.000	.747	.5298	(376*)
303.1	.187	.374		1.00	0.99	.749	.5260	(374*)
295.1	.237	.474		1.00	.99	.843	.4231	(374)
296.1	.209	.418	0.121	0.96	.95	.864	.4716	(247†)
285.1	.255	.510		.50	.50	.875	.2925	(374‡)
302.4	.260	.520		1.004	.996	.883	.3837	(376*)
291.1	.262	.524		1.00	.99	.887	.3795	(374*)
292.6	.306	.612		1.005	.995	.958	.3129	(376*)
285.1	.326	.652		1.0	.99	.989	.2846	(374*)
286.5	.337	.674		0.993	.984	1.005	.2694	(376*)
285.1	.379	.758		1.5	1.48	1.066	.2775	(374‡)
292.6	.393	.786		2.1	2.08	1.086	.3109	(376‡)
291.1	.415	.830		2.0	1.98	1.116	.2802	(563–565†)
285.1	.417	.834		2.0	1.98	1.118	.2781	(374*)
276.6	.422	.844		1.0	0.99	1.125	.1725	(374*)
292.8	.442	.884		3.2	3.15	1.151	.3199	(376‡)
285.1	.443	.886		2.5	2.48	1.153	.2838	(374‡)
291.1	.444	.888		2.5	2.48	1.154	.2834	(563–565†)
285.1	.474	.948		3.0	2.95	1.192	.2801	(374‡)
291.1	.508	1.016		4.0	3.93	1.234	.2915	(563–565†)
292.1	.516	1.032		4.7	4.58	1.244	.3070	(376‡)
285.1	.519	1.038		4.0	3.93	1.248	.2822	(374‡)
296.1	.206	0.412	0.965	0.96	0.95	1.258	.4780	(247†)
292.3	.548	1.096		5.6	5.48	1.282	.3068	(376‡)
292.3	.575	1.150		6.2	6.05	1.313	.3002	(376)
292.6	.607	1.214		7.5	7.35	1.349	.3049	(376)
285.1	.612	1.224		6.0	5.84	1.355	.2721	(374‡)
291.8	.671	1.342		9.0	8.80	1.418	.2874	(376‡)
291.1	.700	1.400		10.0	9.62	1.449	.2819	(563–565†)
291.1	.836	1.672		16.0	14.92	1.584	.2684	(563–565)
291.1	.888	1.776		18.0	16.76	1.632	.2590	(563–565)
291.1	.888	1.776		35.0	30.17	1.632	.3441	(563–565)
291.1	.888	1.776		56.0	43.46	1.632	.3969	(563–565†§)
296.1	.210	0.420	2.21	0.96	0.95	1.685	.4696	(247†)
296.1	.190	.380	3.11	.96	.95	1.918	.5129	(247)
296.1	.178	.356	4.82	.96	.95	2.314	.5414	(247)
296.1	.105	.210	7.50	.96	.95	2.795	.7705	(247)

T	log $p.f.$	$\Delta F^0/T$	Lit.
276.6	0.455	8.25	(374*)
285.1	.568	7.80	(374*)
291.1	.568	7.80	(563–565†)
291.1	.670	9.20	(374*)
293.1	.709	9.74	(1515)
295.1	.709	9.74	(374*)
296.1	.756	10.38	(247†)
303.1	.806	11.07	(374*)
313.1	.919	12.62	(374*)
323.1	1.006	13.82	(374*)

* 1 atm. series (374, 376). § Solid phase, $Mg(HCO_3)_2$.

† Concentrations in molalities.

‡ Varying pressure series (374, 376).

$Mg(HCO_3)_2(s)$ = Mg^{++} + $2HCO_3^-$ (1191) *from* (565)

$\Delta H = -5\ 300$; $\Delta F^0_{298.1} = 370$

T	$m_{(Mg^{++})}$	log $(1/m_\pm)$	$\mu^{1/2}$	log $p.f.$	$\Delta F^0/T$
273.1	1.011	−0.2054	1.741	−0.024	−0.330
278.1	0.987	−0.1950	1.721	−0.009	−0.124
283.1	.941	−0.1743	1.680	0.022	0.302
291.1	.889	−0.1496	1.635	.057	0.783
303.1	.816	−0.1124	1.565	.110	1.511
313.1	.764	−0.0838	1.514	.148	2.033
323.1	.733	−0.0658	1.482	.172	2.363
333.1	.660	−0.020	1.407	.230	3.159

$Mg[Pt(CN)_4].7H_2O(s)$ = (?) + $xH_2O(g)$ (1029) (E)

Over $H_2SO_4(aq)$

P_{H_2O}	Loss H_2O, Moles	P_{H_2O}	Loss H_2O, Moles
0.01914	0.15	0.01099	0.63
0.01758	0.43	0.00974	0.67
0.01642	0.52	0.00796	0.68
0.01442	0.58		

$Mg_3N_2(s)$ = $3Mg(s)$ + $N_2(g)$ (902)

Ca, Calcium

Ca(l) = Ca(g)

$\Delta F^0 = 91\ 280 + 1.20T \ln T + 0.00076T^2 - 72.866T$ (range 1233 to 1380°K) (1191) *from* (1277); from Pilling (1140) and entropies Ca(β) = Ca(g), $\Delta H_0 = 41290$ and measurements on Ca(β) = Ca(l) give $\Delta H_0 = -9\ 590$; whence $\Delta H_0 = 31\ 700$. Undetermined errors must exist

Ca(α)

ΔH^0, $\Delta F^0 = 0$; $C_p = 4.94 + 0.0042T$; $S^0_{298.1} = 9.546$ (1191) *from* (86, 222, 335, 363, 365, 529, 1073)

Ca(β)

$C_p = 6.2 + 0.00152T$; $S^0_{298.1} = 10.827$; $\Delta F^0 = -140 - 1.26T \ln T + 0.00134T^2 + 7.511T$; $\Delta H^0_{298.1} = 117$; $\Delta F^0_{298.1} = 78$; $\Delta S^0_{298.1} = 0.131$; $\Delta S^0_{298.1}$ from specific heats = 1.281 (1191)

Ca(β) = Ca(l)

$\Delta C_p = 0$; $\Delta H_{M.\ P.} = -9\ 590$ (1191) *from* (198, 1011)

Ca(β) = Ca(g) (1191) *from* (1140)

$\Delta F^0 = 40\ 600 + 1.20T \ln T + 0.00076T^2 - 32.67T$; $\Delta H^0_{298.1} = 40\ 310$; $\Delta S^0_{298.1} = 24.60$; $\Delta F^0_{298.1} = 32\ 980$

T	P	I	ΔH^0*	P (calc.)*
776.1	7.38×10^{-7}	−32.812	41 463	8.36×10^{-7}
826.1	2.99×10^{-6}	−32.541	41 766	3.57×10^{-6}
878.1	1.225×10^{-5}	−32.546	41 834	1.67×10^{-5}
881.1	1.474×10^{-5}	−32.762	41 648	1.81×10^{-5}
925.1	8.079×10^{-5}	−34.047	40 512	5.29×10^{-5}
973.1	2.276×10^{-4}	−34.040	40 514	1.52×10^{-4}

* From Ca(g); $S^0_{298.1} = 36.71$ whence $I = -33.952$; $\Delta H_0 = 41\ 290$; $\Delta H^0_{298.1} = 40\ 870$; $\Delta F^0_{298.1} = 33\ 285$.

Ca(α) = Ca(β)

$\Delta H_{673.1} = 100 \pm 25$; *see* Ca(β)

Ca(s) = Ca^{++}; $E^0_{300.1} = 2.77$ (1418)

$Ca.6NH_3(s)$ = Ca(s) + $6NH_3(g)$ (103, 793) (E)

T	P	T	P
262.1	0.0230	294.8*	0.114
273.1*	0.0300	304.3	0.204
283.9*	0.0605	316.8*	0.4035
290.4	0.0908	$\Delta H = 61\ 920$	

* From (793); all other values from (103).

CaO(s); $C_p = 11.0 + 0.0008T$ (1191)

$CaO(s) = Ca(g) + \frac{1}{2}O_2(g)$; At 2000°K, $P_{O_2} = 0.0002$ (157)

$CaO(s) = CaO(g)$; $P_{2000} = 0.0003$ (157)

$CaO_2(s) = CaO(s) + \frac{1}{2}O_2(g)$ *from* (79)

T	P	I*	I†	I‡
473.1	0.1228	−16.35	−10.50	−31.85
523.1	.1330	−15.51	−10.52	−29.83
573.1	.1411	−15.35	−10.50	−28.14
623.1	.1632	−15.16	−10.71	−26.92
673.1	.1998	−15.15	−11.03	−26.04

* Upper temp. range gives $\Delta F^0 = 3\ 470 - 15.2T$; $\Delta F^0_{298.1} = -1\ 060$.

† Lower temp. range gives $\Delta F^0 = 700 - 10.5T$; $\Delta F^0_{298.1} = -2\ 430$.

‡ de Forcrand (435) found $\Delta H = 10\ 800$; or $\Delta F^0 = 10\ 800 - 28.56T$; $\Delta F^0_{298.1} = 2\ 290$.

$CaH_2(s)$; $C_p = 10.3 + 0.0066T$ (1191)

$CaH_2(s) = CaH_2(l)$

$\Delta F^0_{1089.3} = 0$ (745.5)

$CaH_2(s) = Ca(\beta) + H_2(g)$

$\Delta F^0 = 47\ 370 - 2.4T \ln T + 0.00209T^2 - 22.778T$ (range 914 to 1020°K); $\Delta H^0_{298.1} = 47\ 900$; $\Delta F^0_{298.1} = 36\ 690$ (1191) *from* (198); $\Delta H^0_{291.1} = 45\ 100$ (528); *cf.* (394, 794)

$CaH_2(s) = Ca(l) + H_2(g)$ (1011)

T	P	T	P
1 053.1	0.0145	1 236.1	0.465
1 098.1	.0592	1 259.1	.580
1 146.1	.125	1 279.1	.716
1 190.1	.243	1 300.1	.928

$Ca(OH)_2(s) = Ca^{++} + 2OH^-$

$\Delta F^0_{298.1} = 6\ 960$ (1191)

$Ca(OH)_2(s) = CaO(s) + H_2O(g)$ (353, 711) (E)

$\Delta H_{291.1}$ (Thomsen) 25 190; ΔH calculated by equation $d \ln P/dt = \Delta H/RT^2 = 25\ 400$

T	P	T	P
574.1*	0.00350	701.1	0.072‡
593.8*	0.00708	707.1	0.084
603.1*	0.00976	717.1*	0.2308
606.9*	0.01103	721.1	0.121‡
609.6*	0.01218	721.1	0.125†
613.7*	0.01388	731.1	0.158
614.8*	0.01440	740.1	0.191†
620.7*	0.01762	741.1	0.196‡
622.8*	0.01863	759.1	0.305
639.1	0.013†	761.1	0.308‡
642.1	0.0121‡	773.1	0.417†
650.1	0.021†	776.1	0.439†
662.1	0.0229‡	780.1	0.467†
663.1	0.032†	780.1	0.476
663.8*	0.0617†	797.1	0.668†
670.1	0.032†	797.1	0.695
674.2*	0.0805†	800.1	0.692†
681.1	0.0414‡	804.1	0.879
690.1	0.046†	812.1	0.863†
694.4*	0.1332†	830.1	1.000‡

* From (353); all other values from (711). The values of Dragert and Johnston differ materially. It is difficult to say which are the better values.

† Average of two determinations at neighboring temperatures.

‡ Interpolated according to equation: $t = 1.98t_w + 349$, where t = temperature of substance and t_w = temperature of H_2O corresponding to pressure P.

$CaCl_2$ (lowest hydrate) $= CaCl_2(s) + xH_2O(g)$ (69) (E)

T	P	T	P
273.1	0.00009	323.1	0.00176
298.1	0.00045		

$CaCl_2.2H_2O(s) = CaCl_2.H_2O(s) + H_2O(g)$ (1252); *cf.* (1036, 1037) (E)

T	P	T	P
338.1	0.017	428.1	0.576
351.1	0.032	438.1	0.799
373.1	0.079	443.1	0.941
402.1	0.230	448.6	1.108

$CaCl_2.4H_2O$ (α-s) $= CaCl_2.2H_2O(s) + 2H_2O(g)$ (1252); *cf.* (1036, 1037) (E)

T	P	T	P
258.1	0.00022	303.1	0.00610
273.1	0.00078	308.1	0.00824
283.1	0.00164	313.1	0.01122
293.1	0.00326	318.4	0.01549
298.1	0.00447		

$CaCl_2.6H_2O(s) = CaCl_2.4H_2O$ (α-s) $+ 2H_2O(g)$ (1252); *cf.* (843, 844, 1036, 1037) (E)

T	P	T	P
258.1	0.00036	293.1	0.00497
273.1	0.00121	298.1	0.00668
283.1	0.00253	302.9	0.00895

$CaCl_2.6H_2O(s) = CaCl_2.4H_2O$ (β-s) $+ 2H_2O(g)$ (1252); *cf.* (1036, 1037) (E)

T	P	T	P
258.1	0.00029	293.1	0.00414
273.1	0.00100	298.1	0.00568
283.1	0.00213	302.3	0.00746

$CaCl_2.NH_3(s) = CaCl_2(s) + NH_3(g)$ (653) (E)

T	P	T	P
381.8	0.0041	487.8	1.089
426.6	0.088	$\Delta H = 16\ 500$	

$CaCl_2.2NH_3(s) = CaCl_2.NH_3(s) + NH_3(g)$ (653) (E)

T	P	T	P
381.7	0.0503	426.6	0.588
399.1	0.132	453.1*	1.000*
409.7	0.230	$\Delta H = 15\ 100$	

* Extrapolated (666).

$CaCl_2.4NH_3(s) = CaCl_2.2NH_3(s) + 2NH_3(g)$ (653, 666); *cf.* (153) (E)

T	P	T	P
273.1	0.086	306.1	0.654
283.1*	0.168	310.1*	0.778
287.1	0.207	315.1	1.000†
291.1	0.262	319.1*	1.241
299.5*	0.418	326.1*	1.603
	$\Delta H = 20\ 200$		

* From (666); all other values from (653). † Interpolated.

$CaCl_2.8NH_3(s) = CaCl_2.4NH_3(s) + 4NH_3(g)$ (379, 653, 666) (E)

T	P	T	P
267.6	0.094	297.1	0.632
273.1	0.147	298.7*	0.697
273.1*	0.186	301.1†	0.921
279.1	0.205	301.1	0.816
283.1	0.264	305.1	0.917
284.3*	0.317	306.1	1.000‡
287.1†	0.388	303.7*	1.053
287.5*	0.375	312.1*	1.422
293.1	0.500	316.6*	1.778
293.5*	0.513	$\Delta H = 39\ 200$†	

* From (666). † From (653); all other values from (379). ‡ Interpolated.

$CaCl_2.CH_3COCH_3(s) = (?) + xCH_3COCH_3(g)$ (41) (E)

T	P	T	P
310.1	0.007	337.1	0.066
323.1	0.020		

$CaCl_2.2CH_3COCH_3(s) = CaCl_2.CH_3COCH_3(s) + CH_3COCH_3(g)$ (41) (E)

T	P	T	P
293.1	0.054	322.1	0.629
299.1	0.114	327.1	0.820
304.1	0.183	330.1	0.980
309.1	0.263	333.1	1.105
315.1	0.395	335.1	1.214

$CaBr_2$ (lowest hydrate) $= CaBr_2 + xH_2O(g)$ (70) (E)

T	P	T	P
273.1	0.00012	323.1	0.00025
298.1	0.00024		

$CaBr_2.NH_3(s) = CaBr_2(s) + NH_3(g)$ (653) (E)

T	P	T	P
488.1	0.151	503.1	0.255
	$\Delta H = 18\ 600$		

$CaBr_2.2NH_3(s) = CaBr_2.NH_3(s) + NH_3(g)$ (653) (E)

T	P	T	P
410.1	0.013	488.1	0.592
426.1	0.0454	$\Delta H = 17\ 100$	

$CaBr_2.6NH_3(s) = CaBr_2.2NH_3(s) + 4NH_3(g)$ (653) (E)

T	P	T	P
273.1	0.0067	350.1	0.549
336.5	0.295	351.3	0.588
	$\Delta H = 46\ 800$		

$CaBr_2.8NH_3(s) = CaBr_2.6NH_3(s) + 2NH_3(g)$ (653) (E)

T	P	T	P
273.1	0.153	296.1	0.636
	$\Delta H = 19\ 600$		

$CaI_2.4SO_2(s) = (?) + xSO_2(g)$ (392) (E)

T	P	T	P
273.1	0.074	300.6	0.638
289.1	0.099	306.1	1.000
290.6	0.316	$\Delta H =$ *ca.* 10 700x	

$CaI_2.NH_3(s) = CaI_2(s) + NH_3(g)$ (653) (E)

T	P	T	P
488.1	0.061	503.1	0.100
	$\Delta H = 19\ 500$		

$CaI_2.2NH_3(s) = CaI_2.NH_3(s) + NH_3(g)$ (653) (E)

T	P	T	P
427.1	0.0036	503.1	0.170
488.1	0.103	$\Delta H = 19\ 000$	

$CaI_2.6NH_3(s) = CaI_2.2NH_3(s) + 4NH_3(g)$ (653); *cf.* (153) (E)

T	P	T	P
380.1	0.115	409.8	0.401
409.4	0.383	$\Delta H = 56\ 000$	

$CaI_2.8NH_3(s) = CaI_2.6NH_3(s) + 2NH_3(g)$ (653) (E)

T	P	T	P
194.8	0.0017	252.1	0.461
233.1	0.038	261.1	0.891
	$\Delta H = 17\ 200$		

$CaSO_3.2H_2O(s) = Ca^{++} + SO_3^{--} + 2H_2O(l); \Delta F^0_{298.1} = 9\ 740$ (89)

$CaSO_3.2H_2O(s) + S = Ca^{++} + S_2O_3^{--} + 2H_2O(l)$ (89)

T		m
352.9	S (rhomb)	1.120
373.1	S (monocl)	0.713
383.1	S (monocl)	0.618
395.1	$S_{\lambda,\ \mu}$(l)	0.417
414.1	$S_{\lambda,\ \mu}$(l)	0.2665

$CaSO_4(s) = CaO(s) + SO_2(g) + \frac{1}{2}O_2(g)$ (149, 636)

$CaSO_4.\frac{1}{2}H_2O(s) = CaSO_4(s) + \frac{1}{2}H_2O(g)$ (843) (E)

T	P	T	P
373.1	0.0230	421.1	0.220
387.1	0.037	434.6	0.395
397.1	0.0586		

$CaSO_4.2H_2O(s) + 2NH_4OH(aq) = Ca^{++} + 2NH_4^+ + SO_4^{--} + 2OH^- + 2H_2O(l)$ (1064)

$Ca(OH)_2(s) + SO_4^{--} + H_2O = CaSO_4.2H_2O(s) + 2OH^-$ (1066)

$c_{(OH^-)}$	$c_{(SO_4^{--})}$	$c_{(Ca^{++})}$	K_c
	$T = 288.1°K$		
0.1786	0.702	0.00250	0.0454
.1818	.925	.00250	.0357
.1625	.437	.00271	.0604
.1632	.431	.00268	.0617
.1370	.199	.00325	.0942
.1357	.193	.00332	.0952
.0972	.0674	.00571	.140
.0968	.0682	.00526	.138
.0737	.0326	.00696	.167
.0745	.0336	.00687	.165
	$T = 313.1°K$		
0.1314	0.460	0.00152	0.0376
.1305	.455	.00153	.0375
.1086	.216	.00232	.0545
.1119	.218	.00225	.0573
.0770	.072	.00401	.0827
.0776	.077	.00392	.0783
.0596	.0374	.00517	.0950
.0576	.044	.00544	.0760
	$T = 343.1°K$		
0.1212	0.713	0.00071	0.0207
.1024	.477	.00098	.0221
.1118	.4810	.00089	.0259
.0675	.2287	.00130	.0334
.0864	.2241	.00134	.0332
.0596	.0822	.00241	.0433
.0588	.0832	.00244	.0416
.0440	.0383	.00357	.0506
.0436	.0355	.00360	.0535
	$T = 373.1°K$		
0.1054	0.727	0.00018	0.0153
.1092	.930		.0128
.0904	.487	.00041	.0167
.0880	.478	.00045	.0162
.0708	.243	.00082	.0206
.0693	.234	.00089	.0205
.0485	.0912	.00187	.0258
.0499	.0908	.00178	.0274
.0334	.0482	.00303	.0230
.0360	.0472	.00271	.0274

$CaSO_4.2H_2O(s) = CaSO_4.\frac{1}{2}H_2O(s) + 1\frac{1}{2}H_2O(g)$ (634.5,* 843) (E)

T	P	T	P
290.1	0.00661	345.1	0.2366
298.1	0.0120	350.2	0.3136
321.1	0.0617	355.85	0.4209
323.1	0.0651	373.1†	0.881–0.942
333.1	0.1180	374.55	0.9984
	$\Delta H = 3\ 921$		

* Values of P also calculated according to equation: $\log P = \log P_w + 1.493 - 567.7/T$ where P_w = the vapor pressure of the water.

† From (843).

$CaSO_4.2H_2O(s) = CaSO_4$ (soluble anhydrite) $+ 2H_2O(g)$ (634.5*) (E)

T	P	T	P
288.4	0.0096	333.1	0.1417
298.1	0.0188	345.1	0.2712
321.9	0.0759	$\Delta H = 4\ 740$, Thomsen	

* Also gives calculated values, according to equation: $\log P = \log P_w + 1.407 - 514.6/T$ where P_w = vapor pressure of the water.

$CaSO_4.2H_2O(s) = CaSO_4$ (natural anhydrite) $+ 2H_2O(g)$ (E) $\Delta H = 4\ 606$ (634.5); calculated values of P according to equation:

$$\log P = \log P_w + 1.486 - 500/T$$

$CaS_2O_3.6H_2O(s) + SO_4^{--} = CaSO_4.2H_2O(s) + S_2O_3^{--} + 4H_2O(l)$

$K_{282.1} = 7\ 940 \times 10^4$; $K_{298.1} = 9\ 475 \times 10^4$ (795.5)

$CaS_2O_3.6H_2O(s) + CO_3^{--} = CaCO_3(s) + S_2O_3^{--} + 6H_2O(l)$

$K_{298.1} = 10^2$ (795.5)

$Ca(NO_3)_2.2H_2O^*(s) = Ca(NO_3)_2.(?)H_2O(s) + 2H_2O(g)$

$P_{303.1} = 0.0036$ (843)

* Composition uncertain.

$Ca(NO_3)_2.3H_2O(s) = Ca(NO_3)_2.2H_2O^*(s) + H_2O(g)$ (843) (E)

T	P	T	P
288.1	0.0013	313.1	0.0080
303.1	0.0047		

* Composition uncertain.

$Ca(NO_3)_2.4H_2O(s) = Ca(NO_3)_2.3H_2O(s) + H_2O(g)$ (843) (E)

T	P	T	P
283.1	0.0014	308.1	0.0096
293.1	0.0025	313.1	0.0126
303.1	0.0058		

$CaCO_3$ (aragonite) $+ CO_2(g) + H_2O(l) = Ca^{++} + 2HCO_3^-$ (1191) *from* (39)

$\Delta S^0_{298.1} = -54.807$; $\Delta H^0_{298.1} = -8\ 550$; $\Delta F^0_{298.1} = 7\ 788$

T	$c_{(Ca^{++})}$	$c_{(HCO_3^-)}$	f_{CO_2}	$\mu^{1/2}$	$\log(1/K_c^{1/3})$
308.1	0.00876	0.01752	0.969	0.162	1.8522
298.1	.01066	.02132	.992	.179	1.7703
282.1	.0146	.0292	1.012	.209	1.6366

T	$\log p.f.$	$\Delta F^0/T$
282.1	1.783	24.49
298.1	1.901	26.11
308.1	1.974	27.12

$CaCO_3$ (calcite) $+ CO_2(g) + H_2O(l) = Ca^{++} + 2HCO_3^-$ (1191) *from* (39, 263, 374, 563, 564, 565, 719, 752, 975, 1319, 1514, 1515); *cf.* (241, 244, 245, 371)

$\Delta S^0_{298.1} = -55.579$; $\Delta H^0_{298.1} = -8\ 588$; $\Delta F^0_{298.1} = 7\ 980$

T	$c_{(Ca^{++})}$	$c_{(HCO_3^-)}$	p_{CO_2}	f_{CO_2}	$\mu_c^{1/2}$	$\log(1/K_c^{1/3})$	Lit.
323.1	0.000293	0.000586		0.000300	0.030	2.1581	(752)
298.1	.000461	.000922		.000300	.037	1.9595	(752)
303.1	.00055	.00110		.000315	.041	1.8916	(1514, 1515)
296.1	.00057	.00114		.000315	.041	1.8761	(1514, 1515)
295.1	.00057	.00114		.000315	.041	1.8761	(1514, 1515)

$CaCO_3$(calcite) $+ CO_2(g) + H_2O(l)$.—*(Continued)*

T	$c_{(Ca^{++})}$	$c_{(HCO^{\bar{3}})}$	p_{CO_2}	f_{CO_2}	$\mu_c^{1/2}$	$\log(1/K_c^{1/3})$	Lit.
294.1	0.00059	0.00118		0.000315	0.042	1.8612	(1514, 1515)
294.1	.00061	.00122		.000315	.043	1.8466	(1514, 1515)
289.1	.000747	.001462		.000500	.047	1.8323	(1319)
274.1	.00082	.00164		.000315	.050	1.7182	(1514, 1515)
289.1	.000850	.001674		.000800	.051	1.8419	(1319)
289.1	.001372	.002728		.00330	.064	1.8364	(1319)
289.1	.002231	.004452		.01374	.082	1.8296	(1319)
289.1	.002965	.005922		.02792	.094	1.8096	(1319)
289.1	.003600	.007194		.04958	.104	1.8082	(1319)
289.1	.005330	.010656		.1408	.127	1.7882	(1319)
289.1	.006634	.013264		.2513	.141	1.7776	(1319)
308.1	.007650	.015300		.969	.151	1.9110	(39)
289.1	.007875	.015748		.4125	.154	1.7751	(1319)
289.1	.008855	.017708		.5478	.163	1.7650	(1319)
298.1	.009430	.018860		.992	.168	1.8236	(39)
289.1	.009720	.019440		.7224	.175	1.7646	(1319)
289.1	.010860	.021720		.9743	.180	1.7609	(1319)
289.1	.010850	.021700	1.0	.99	.180	1.7622	(374)
288.1	.01175	.02350		.92	.188	1.7235	(263)
282.1	.0130	.0260		1.012	.198	1.6871	(39)
289.1	.014110	.028220	2.0	1.98	.206	1.7485	(374)
273.1	.0156	.0312		0.92	.216	1.5967	(263)
289.1	.018340	.036680	4.0	3.93	.235	1.7340	(374)
289.1	.021390	.042780	6.0	5.84	.253	1.7247	(374)
328.1	.0255	.0510	56.0	46.93	.277	1.9499	(563–565)
291.1	.0256	.0512	10.0	9.62	.277	1.7188	(563–565)
291.1	.0283	.0566	14.0	13.24	.291	1.7214	(563–565)
291.1	.0307	.0614	18.0	16.76	.303	1.7203	(563–565)
218.1	.0339	.0678	56.0	45.92	.319	1.8231	(563–565)
391.1	.0342	.0684	25.0	22.58	.320	1.7164	(563–565)
291.1	.0380	.0760	35.0	30.17	.338	1.7127	(563–565)
308.1	.0380	.0760	56.0	44.97	.338	1.7704	(563–565)
291.1	.0393	.0786	56.0	43.46	.343	1.7509	(563–565)
298.1	.0403	.0806	56.0	44.07	.348	1.7420	(563–565)

T	$\log p.f.$	$\Delta F^0/T$	Lit.
273.1	1.747	24.00	(263)
274.1	1.763	24.20	(1514, 1515)
282.1	1.828	25.11	(39)
288.1	1.860	25.55	(263)
289.1	1.892	25.99	(374)
289.1	1.892	25.99	(1319)
291.1	1.951	26.79	(563–565)
294.1	1.886	25.89	(1514, 1515)
294.1	1.898	26.08	(1514, 1515)
295.1	1.914	26.28	(1514, 1515)
296.1	1.914	26.28	(1514, 1515)
298.1	1.949	26.77	(39)
298.1	1.944	26.70	(563–565)
298.1	1.994	27.39	(752)
298.1	1.949	26.77	(975)
303.1	1.929	26.50	(1514, 1515)
308.1	2.026	27.83	(39)
308.1	1.969	27.03	(563–565)
318.1	2.015	27.68	(563–565)
323.1	2.184	30.00	(752)
328.1	2.079	28.56	(563–565)

$CaCO_3$ (calcite) $+ H_2CO_3(aq) = Ca^{++} + 2HCO_3^-$ (1191) *from* (975, 1340)

$\log p.f._{298.1} = 1.458$; $\Delta F^0_{298.1} = 5\ 970$

$c_{(H_2CO_3)}$	$c_{(Ca^{++})}$	$c_{(HCO_3^-)}$	$\mu_c^{1/2}$	$\log(1/K_c^{1/3})$	Lit.
0.00269	0.00370	0.00740	0.105	1.3744	(1340)
.00104	.00363	.00244	.110	1.3595*	(1340)
.00363	.00414	.00828	.111	1.3685	(1340)
.00352	.00412	.00824	.111	1.3666	(975)
.00181	.00423	.00304	.117	1.3545*	(1340)
.00206	.00436	.00317	.119	1.3572*	(1340)
.00475	.00278	.01181	.121	1.3627†	(1340)
.00315	.00473	.00364	.124	1.3676*	(1340)

$CaCO_3$(calcite) + H_2CO_3(aq).—(*Continued*)

$c_{(H_2CO_3)}$	$c_{(Ca^{++})}$	$c_{(HCO_3^-)}$	$\mu_c^{1/2}$	log $(1/K_c^{1/2})$	Lit.
0.00406	0.00170	0.01590	0.133	1.3251‡	(1340)
.00455	.00560	.00441	.134	1.3393*	(1340)
.0100	.00604	.01208	.135	1.3516	(1340)
.00395	.00931	.00612	.136	1.3514§	(1340)
.00656	.00611	.00492	.139	1.3814*	(1340)
.0114	.00657	.01314	.140	1.3340	(1340)
.00356	.00662	.00350	.152	1.3468‖	(1340)
.0373	.00973	.01946	.171	1.3351	(975)
.00494	.01004	.00379	.191	1.3109¶	(1340)
.00256	.00406	.00812	.193	1.3269**	(1340)
.00310	.00412	.00824	.193	1.3482††	(1340)
.00444	.00461	.00922	.197	1.3513‡‡	(1340)
.001875	.00366	.00732	.227	1.3272§§	(1340)
.333	.0224	.0448	.259	1.2897	(975)
.444	.0250	.050	.274	1.2838	(975)
.550	.0260	.052	.279	1.2976‖‖	(975)
.858	.0260	.052	.279	1.3620‖‖	(975)

* 0.00199M_c $CaSO_4$ added. † 0.00625M_c $NaHCO_3$ added. ‡ 0.0125M_c $NaHCO_3$ added. § 0.00625M_c $CaCl_2$ added. ‖ 0.00312M_c $CaSO_4$ added. ¶ 0.00625M_c $CaSO_4$ added. ** 0.00625M_c NaCl added. †† 0.0125M_c NaCl added. ‡‡ 0.0625M_c $MgSO_4$ added. §§ 0.0125M_c Na_2SO_4 added. ‖‖ Solid phase $Ca(HCO_3)_2$. (M_c = Moles per liter.)

$CaCO_3(s) = CaO(s) + CO_2(g)$ (1390.5) (E)

$\Delta F^0 = 42\ 216 - 2.4T \ln T + 0.00355T^2 + 0.0000031T^3 - 23.698T$ (1181) *from* (1390.5); or $-23.753T$ (1191) *from* (718); $\Delta F^0_{298.1} = 31\ 384$ (1191)

T	P	T	P
1 115.4	0.4513	1 210.1	1.770
1 126.0	0.5245	1 322.4	6.439
1 127.6	0.5317	1 355.6	8.892
1 142.0	0.6722	1 430.8	18.687
1 177.4	1.157	1 499.4	34.333
1 179.6	1.151	1 514.0	39.094

$\Delta H = 43\ 300$, Berthelot

The various forms of $CaCO_3$, chalk, marble, calcite and aragonite give identical values within the accuracy of the measurements. For pressure values above the eutectic temperature, *see* the original article.

$CaCO_3$ with only 0.38% CaO melts at 1662.1°K and has at that temperature a pressure of 1.025 atm.

The formula: $\log P = -11\ 355/T - 5.388 \log T + 26.238$, calculated from the experimentally determined values, gives:

T	P*	T	P*
773.1	0.000096	1 173.1	1.043
823.1	0.00054	1 223.1	2.075
873.1	0.00242	1 273.1	3.871
923.1	0.00908	1 323.1	6.837
973.1	0.0292	1 373.1	11.499
1 023.1	0.0832	1 423.1	18.092
1 073.1	0.220	1 473.1	28.680
1 123.1	0.489	1 513.1	39.66
1 170.1	1.000		

* In good agreement with these values (1394) finds $P = 0.000004$–0.000012 at 673.1°K; *cf.* (1154, 1227, 1560).

Johnston (718) worked with very small quantities of materials and found $P = 1$ atm. at 1171.1°K. According to Johnston, P can be calculated according to the formula:

$\log P = -9\ 340/T + 1.1 \log T - 0.0012T + 6.001$. By the hastening of equilibrium through the addition of basic compounds such as Li_2CO_3 or Na_2CO_3, Zavrieff (1560) obtained somewhat higher pressures at lower temperatures, but on the other hand lower pressures at the higher temperatures. ($P = 1$ atm. at 1182.1°K.) The values of Riesenfeld (1227) occupy a mean position. He gives the equation: $\log P = -9\ 300/T + 1.75 \log T + 0.011916T - 20\ 323 \times 10^{-9}T^2 + 82\ 446 \times 10^{-13}T^3 + 0.319$; *cf.* (180, 453, 525, 839).

According to Lebeau (836), mixtures with alkali carbonates have a lower CO_2 pressure than the pure $CaCO_3$; they also include double carbonates; *cf.* (837).

$CaSO_4.2H_2O(s) + CO_3^{--} = CaCO_3(s) + SO_4^{--} + 2H_2O(l)$

With NH_4^+ (1063)

$CaCO_3$ (calcite) = $CaCO_3$ (aragonite)

$\Delta S^0_{298.1} = 0.772$; $\Delta H_{298.1} = 38$; $\Delta F^0_{298.1} = -192$ (1191) *from* (39)

$Ca(HCO_3)_2(s) = Ca^{++} + 2HCO_3^-$

$\Delta F^0_{298.1} = 6\ 399$ (1191)

$CaCO_3$ (calcite) + $H_2CO_3(aq) = Ca(HCO_3)_2(s)$

$\Delta F^0_{298.1} = -429$ (1191) *from* (975)

$CaCO_3$ (calcite) + $C_2O_4^{--} = CaC_2O_4(s)$ (oxalate) + CO_3^{--} (1191)

from (429, 1167, 1168)

$\Delta H_{298.1} = -7\ 460$; $\Delta F^0_{298.1} = -306$ (1191)

T	$c_{(K_2C_2O_4)}$	$c_{(K_2CO_3)}$	$c_{(KCl)}$	μ_c	K_c
298.1	0.080	0.303	0.034	1.183	3.8
298.1	.084	.299	.034	1.183	3.6
298.1	.1869	.3131		1.50	1.675
298.1	.159	.607	.068	2.37	3.8
298.1	.160	.606	.068	2.37	3.8
298.1	.166	.600	.068	2.37	3.6
322.8	.3062	.1938		1.50	0.633
332.1	.3531	.1469		1.50	.416
369.1	.266	.117		1.183	.44

$CaCO_3$ (aragonite) + $C_2O_4^{--} = CaC_2O_4(s)$ (oxalate) + CO_3^{--}

(1191) *from* (429)

$\Delta H_{298.1} = -7\ 225$; $\Delta F^0_{298.1} = -484$

T	$c_{(K_2C_2O_4)}$	$c_{(K_2CO_3)}$	μ_c	K_c
298.1	0.1532	0.3467	1.50	2.262
322.8	.2682	.2318	1.50	0.864
332.1	.3302	.1698	1.50	.514

$CaC_2(s) + N_2(g) = CaCN_2(s) + C$ (graph.) (1439)

$CaC_2(s) = Ca(g) + 2C$ (graph.) (111, 1438)

$CaO(s) + 3C$ (graph.) $= CaC_2(l,s) + CO(g)$ (129, 426, 816, 1266, 1271, 1437, 1438, 1439)

$CaCN_2(s) + C + 2NaCl(l) = CaCl_2(l) + 2NaCN(l)$ (449, 818)

$Ca(CNS)_2.\frac{1}{2}SO_2(s) = (?) + xSO_2(g)$ (392) (E)

T	P	T	P
268.1	0.046	292.6	0.362
273.1	0.086	300.6	0.562
284.6	0.224	307.1	1.000 (extrap.)

$\Delta H = 10\ 740x$

$CaSO_4(s) + SiO_2(s) = CaSiO_3(s) + SO_2(g) + \frac{1}{2}O_2(g)$

$P_{1546} = 1.00$ (extrap.) (950)

$CaSO_4(s) + Al_2O_3(s) = CaAl_2O_4(s) + SO_2(g) + \frac{1}{2}O_2(g)$

$P_{1636} = 1.00$ (extrap.) (950)

$Ca_3N_2(s) = 3Ca(l) + N_2(g)$

$\log p = -24\ 360/T + 13.285$ (794)

Sr, Strontium

$Sr.6NH_3(s) = Sr(s) + 6NH_3(g)$ (656) (E)

T	P	T	P
273.1	0.0555	293.1	0.175
278.6	0.071	297.1	0.207
284.1	0.103	300.1	0.255
287.6	0.120	306.6	0.362*
291.1	0.154	319.1	1.000*

$\Delta H = 59\ 460$

* Extrapolated from Roederer (1238).

$SrH_2(s) = Sr(s) + H_2(g)$ (394)

$Sr(OH)_2(aq) = Sr^{++} + 2OH^-$ (780, 781)

$Sr(OH)_2(s) = SrO(s) + H_2O(g)$ (711, 718) ((E)

T	P	T	P
703.1	0.0089	907.1	0.196
725.1	0.0121	912.1	0.217
733.1	0.0141	943.1	0.308
743.1	0.0158	952.1	0.367
761.1	0.0229	962.1	0.413
776.1	0.0276	979.1	0.467
797.1	0.0414	994.1	0.567
819.1	0.054	1 013.1	0.689
834.1	0.072	1 015.1	0.692
870.1	0.109	1 027.1	0.811
870.1	0.121	1 038.1	0.862
901.1	0.197	1 051.1	1.000

$\Delta H = 27\ 350$ (Thomsen); $\Delta H = 20\ 700$; $t = 3.62t_w + 416$, where t_w = the temperature at which the pressure of pure water is equal to that of the substance at the temperature t.

$Sr(OH)_2.H_2O(s) = Sr(OH)_2(s) + H_2O(g)$ (1030, 1032) (E)

$Sr(OH)_2.7H_2O(s) = Sr(OH)_2.H_2O(s) + 6H_2O(g)$ (1030, 1032) (E)

$Sr(OH)_2.8H_2O(s) = Sr(OH)_2.7H_2O(s) + H_2O(g)$ (1030, 1032) (E)

$Sr(OH)_2.2H_2O(s) = Sr(OH)_2.H_2O(s) + H_2O(g)$ (711, 718, 844) (E)

T	P	T	P
326.7	0.038	358.1*	0.126
332.2	0.050	361.0	0.141
343.3	0.075	362.6	0.150
352.3	0.107	373.1*	0.314

* From (844); all other values from (711, 718).

$Sr(OH)_2.8H_2O(s) = Sr(OH)_2.2H_2O(s) + 6H_2O(g)$ (711, 718) (E)

$\Delta H = 106\ 800$; $\Delta H = 109\ 980$ (Thomsen)

For the compound of composition $Sr(OH)_2.4.2H_2O$:

T	P	T	P
288.3	0.0146	335.6	0.2003
301.0	0.0313	343.6	0.2888
311.5	0.0589	353.1	0.428
323.4	0.1091	363.2	0.624

$t = t_w + 2.2$, where t_w = the temperature at which the pressure of pure water is equal to that of the substance at temperature t. A material of the composition $Sr(OH)_2.2.2H_2O$ (composed of the 9- and 2-hydrate), shows an average pressure between the two, according to the equation $t = 0.93t_w + 17$ (711, 718). The values of (844) are too low

$SrCl_2.2H_2O(s) = SrCl_2(s) + 2H_2O(g)$ (844) (E)

T	P	T	P
293.1	0.0024	353.1	0.091
313.1	0.0074	373.1	0.309

$SrCl_2.6H_2O(s) = SrCl_2.2H_2O(s) + 4H_2O(g)$ (18, 68, 458, 895, 1335); *cf.* (291, 844, 1325) (E)

Menzies (986) considers the values of (18) to be more accurate than those of Frowein (458); $\Delta H = 12\ 760$, calculated according to van't Hoff equation (458)

T	P	T	P
248.1 (63)	0.00007*	298.1 (63)	0.01101
258.1 (63)	0.00014*	298.1‖	0.01121
273.1 (63)	0.00050	298.76‡	0.01029
287.85‡	0.00432	298.7†	0.01147
288.1 (63)	0.00525	303.0†	0.01557
292.8†	0.00738	303.11‡	0.01430
293.44‡	0.00676	307.2†	0.02083

$SrCl_2.6H_2O(s)$.—(*Continued*)

T	P	T	P
307.3§	0.0186	312.55‡	0.02838
307.76‡	0.02016	313.1 (63)	0.03157*
310.65†	0.02617	323.1 (63)	0.06126*

* Interpolated according to equation: $\log P = 7.785 - 2\,794.1/(T + 152)$.
† From (18). ‡ From (458). § From (895). ‖ From (1335).

$SrCl_2.NH_3(s) = SrCl_2(s) + NH_3(g)$ (654*) (E)

T	P	T	P
273.1	0.083	351.1	0.395
336.1	0.317	381.1	0.541
	$\Delta H = 11\ 500$		

* These values are not very reliable.

$SrCl_2.8NH_3(s) = SrCl_2.(?)NH_3(s) + xNH_3(g)$ (654) (E)

T	P	T	P
273.1	0.105	305.9	0.803
291.1	0.339	$\Delta H = 9\ 900x$	

$SrBr_2.6H_2O(s) = (?) + xH_2O(g)$ (844) (E)

T	P	T	P
293.1	0.0023	313.1	0.0071

$SrBr_2.NH_3(s) = SrBr_2(s) + NH_3(g)$ (654) (E)

T	P	T	P
427.1	0.151	488.1	0.541
	$\Delta H = 16\ 800$		

$SrBr_2.2NH_3(s) = SrBr_2.NH_3(s) + NH_3(g)$ (654) (E)

T	P	T	P
336.1	0.102	350.1	0.363
	$\Delta H = 12\ 800$		

$SrBr_2.8NH_3(s) = SrBr_2.2NH_3(s) + 6NH_3(g)$ (654) (E)

T	P	T	P
273.1	0.012	326.1	0.842
332.1	0.672	$\Delta H = 65\ 400$	

$SrI_2.2SO_2(s) = (?) + xSO_2(g)$ (392) (E)

T	P	T	P
273.1	0.039	315.6	1.000 (extrap.)
	$\Delta H = 11\ 060x$		

$SrI_2.4SO_2(s) = (?) + xSO_2(g)$ (392) (E)

T	P	T	P
273.1	0.118	292.1	0.329
279.1	0.171	307.1	1.000 (extrap.)
286.1	0.245	$\Delta H = 10\ 740x$	

$SrI_2.NH_3(s) = SrI_2(s) + NH_3(g)$ (654) (E)

T	P	T	P
481.1	0.155	503.1	0.330
488.1	0.200	$\Delta H = 18\ 300$	

$SrI_2.2NH_3(s) = SrI_2.NH_3(s) + NH_3(g)$ (654) (E)

T	P	T	P
380.1	0.039	426.1	0.258
410.1	0.151	$\Delta H = 15\ 500$	

$SrI_2.6NH_3(s) = SrI_2.2NH_3(s) + 4NH_3(g)$ (654) (E)

T	P	T	P
336.1	0.087	380.6	0.574
349.7	0.143	$\Delta H = 50\ 400$	

$SrI_2.8NH_3(s) = SrI_2.6NH_3(s) + 2NH_3(g)$ (654) (E)

T	P	T	P
273.1	0.012	324.1	0.439
306.1	0.139	332.6	0.658
309.1	0.174	$\Delta H = 22\ 000$	

$SrCO_3(s) + CO_2(g) + H_2O(l) = Sr^{++} + 2HCO_3^-$ (1191) *from* (564)

$\Delta H_{298.1} = -6\ 740$; $\Delta F^0_{298.1} = 9\ 052$ (1191)

T	$m_{(Sr^{++})}$	p_{CO_2}	f_{CO_2}	$\mu^{1/2}$	log $(1/m_\pm^{1/3})$
291.1	0.00812	1	0.99	0.156	1.8882
291.1	.0257	35*	30.17	.278	1.8826

* And greater pressures.

$SrCO_3(s) + H_2CO_3(aq) = Sr^{++} + 2HCO_3^-$ (1191) *from* (975)

$K_{298.1} = 6.93 \times 10^{-6}$; $\Delta H_{298.1} = -1\ 940$; $\Delta F^0_{298.1} = 7\ 042$

$SrCO_3(s) = SrO(s) + CO_2(g)$ (180, 595); *cf.* (453, 614) (E)

T (180)	P	T (595)	P
1 428.1	1.00	1 418.1	1.00

$Sr(HCO_3)_2 = Sr^{++} + 2HCO_3^-$

$K_{291.1} = 1.83 \times 10^{-5}$; $\Delta F^0_{291.1} = 6\ 314$ (1191) *from* (564)

$SrSiF_6(?) = SrF_2(?) + SiF_4(g)$ (1398) (E)

T	P	T	P
752.7	0.0293	810.1	0.3518
780.6	0.0857	827.3	0.6895
795.7	0.2004	834.7	0.8953
808.6	0.3319	844.2	1.2555

$SrF_2/SrSiF_6 = 0.274$ in solid phase; $\log P = -20\ 680/4.571T + 1.751 \log T + 0.319$.

Ba, Barium

$Ba.6NH_3(s) = Ba(s) + 6NH_3(g)$ (103); *cf.* (981) (E)

T	P	T	P
248.1	0.017	273.1	0.081
261.1	0.037	$\Delta H = 57\ 900$	

$BaO(s) + \frac{1}{2}O_2(g) = BaO_2(s)$ (621); *cf.* (840)

$\Delta F^0_{298.1} = -13\ 200$ (885)

T	P	T	P
891.1	0.0149	1 067.1	0.497
928.1	.0353	1 108.1	.945
970.1	.0861	1 126.1	1.220
1 010.1	.1855	1 141.1	1.534

$BaO_2.10H_2O(s) = Ba^{++} + 2OH^- + H_2O_2(aq) + 8H_2O(l)$

$K_{273.1} = 18.5 \times 10^{-12}$; $\Delta H = 23\ 700$; $K_{298.1} = 7.17 \times 10^{-10}$; $\Delta F^0_{298.1} = 12\ 840$ (877, 885)

$BaO_2.10H_2O(s) = BaO_2(s) + 10H_2O(g)$ (877, 885)

T	P	T	P
295.1	0.0197	304.1	0.0372
298.1	.0245	$\Delta F^0_{298.1} = 22\ 000$	

$BaH_2(s) = Ba(s) + H_2(g)$ (394)

$Ba(OH)_2(l) = BaO(s) + H_2O(g)$ (711, 717) (E)

ΔH (Thomsen) $= 31\ 800$; $\Delta H = 27\ 780$ gives I's as below; $\Delta F^0_{298.1} = 25\ 900$ (885)

T	P	I	T	P	I
903.1	0.0121*		1 130.1	0.278	
918.1	0.0158		1 143.1	0.308*	
943.1	0.0229*	21.945	1 164.1	0.429	
953.1	0.025		1 183.1	0.467*	21.967
983.1	0.0414*		1 187.1	0.507	
1 022.1	0.072	21.958	1 223.1	0.661	
1 022.1	0.074		1 224.1	0.692*	
1 059.1	0.125		1 239.1	0.764	
1 062.1	0.121*		1 263.1	0.921	
1 102.1	0.196*	21.967	1 261.1	1.000*	

* Values calculated from $t = 4.0t_w + 590$, where t = temperature of substance; t_w = temperature of H_2O corresponding to P.

$Ba(OH)_2(aq) = Ba^{++} + 2OH^-$ (780, 781)

$Ba(OH)_2.H_2O(s) = Ba(OH)_2 + H_2O(g)$ (843); *cf.* (1031)

$\Delta H = 14\ 800$; $\Delta F^0_{298.1} = 4\ 650$ (885)

T	P	T	P
350.1	0.018	373.1	0.059

$Ba(OH)_2.8H_2O(s) = Ba^{++} + 2OH^- + 8H_2O(l)$

$\Delta F^0_{298.1} = 3\ 140$ (885)

$Ba(OH)_2.8H_2O(s) = Ba(OH)_2.H_2O(s) + 7H_2O(g)$ (717) (E)

$\Delta F^0_{298.1} = 18\ 350$ (885); ΔH (Thomsen) $= 94\ 500$; $= 93\ 380$ (717)

T	P	T	P
Solid phase: $Ba(OH)_2.7H_2O$			
290.8	0.0047	327.4	0.0604
305.3	0.0130	328.4	0.0675
312.2	0.0222	331.0	0.0791
313.9	0.0233	337.0	0.1204
323.9	0.0501	338.0	0.1241
Solid phase: $Ba(OH)_2.1.3H_2O$			
285.0	0.0022	341.9	0.150
307.1	0.0161	349.0	0.226
331.1	0.0776	356.9	0.346
332.6	0.0850	360.1	0.414

$BaCl_2.H_2O(s) = BaCl_2(s) + H_2O(g)$ (430, 844, 1325); *cf.* (1030, 1325) (E)

$P_{314.1} = 0.0034$

T	P	T	P
298.1*	0.0033	353.1	0.0665
313.1	0.005	373.1	0.357
333.1	0.0269		

* From (430); all other values from (844).

$BaCl_2.2H_2O(s) = BaCl_2.H_2O(s) + H_2O(g)$ (66, 458, 1325); *cf.* (291, 844, 986, 1035, 1036) (E)

$P_{298.1} = 0.0063$ (430); $= 0.00692$ (1113); $= 0.00724$ (1335); $= 0.0076 \pm 0.0001$ (1531); $\Delta H = 3\ 820$ (458); *cf.* (1325)

T	P	T	P
273.1	0.00124*	303.1	0.01063*
283.1	0.00259*	304.75†	0.01077
288.1	0.00372	308.05‡	0.01529
288.1‡	0.00314	308.1	0.01489*
289.1‡	0.00347	309.3†	0.01709
291.35	0.00391	309.55†	0.01677
293.1	0.00532*	309.95†	0.01725
298.1	0.00754	310.4†	0.01774
298.78†	0.00718	313.1	0.02077
299.0†	0.00730	316.55†	0.02779
301.95†	0.00938	323.1	0.03967*
303.05†	0.01047		

* Values calculated according to equation: $\log P = 15.0870 - 9\ 839.59/(T + 273.75)$. † From (458); all other values from (66). Menzies (986) considers the values of (1325) more reliable than those of (458). ‡ From (1325).

$BaCl_2.6H_2O(s) = BaCl_2.2H_2O(s) + 4H_2O(g)$ (844) (E)

T	P	T	P
278.1	0.0071	283.1	0.0099

$BaCl_2.8NH_3(s) = BaCl_2(s) + 8NH_3(g)$ (656) (E)

T	P	T	P
257.6	0.249	262.3	0.378
258.1	0.254	273.1	0.658
$\Delta H = 72\ 000$			

$BaBr_2.H_2O(s) = BaBr_2(s) + H_2O(g)$ (847) (E)

T	P	T	P
313.1	0.030	343.1	0.120
333.1	0.076	348.1	0.151
338.1	0.089		

$BaBr_2.2H_2O(s) = BaBr_2.H_2O(s) + H_2O(g)$ (847) (E)

T	P	T	P
293.1	0.0139	333.1	0.163

$BaBr_2.NH_3(s) = BaBr_2(s) + NH_3(g)$ (656) (E)

T	P	T	P
273.1	0.007	314.1	0.049
	$\Delta H = 11\ 800$		

$BaBr_2.2NH_3(s) = BaBr_2.NH_3(s) + NH_3(g)$ (656) (E)

T	P	T	P
273.1	0.033	306.1	0.288
	$\Delta H = 10\ 600$		

$BaBr_2.4NH_3(s) = BaBr_2.2NH_3(s) + 2NH_3(g)$ (656) (E)

T	P	T	P
273.1	0.064	306.1	0.654
	$\Delta H = 20\ 400$		

$BaBr_2.8NH_3(s) = BaBr_2.4NH_3(s) + 4NH_3(g)$ (656) (E)

T	P	T	P
273.1	0.092	288.1	0.262
277.1	0.132	306.1	0.843
	$\Delta H = 40\ 000$		

$BaI_2.6H_2O(s) = (?) + xH_2O(g)$ (847) (E)

T	P	T	P
293.1	0.0108	333.1	0.079

$BaI_2.2SO_2(s) = (?) + xSO_2(g)$ (392) (E)

T	P	T	P
288.1	0.086	322.1	0.987
302.1	0.191	322.6	1.000 (extrap.)
314.1	0.513	$\Delta H = 11\ 340x$	

$BaI_2.4SO_2(s) = (?) + xSO_2(g)$ (392) (E)

T	P	T	P
273.1	0.500	282.1	0.820
275.6	0.576	285.6	1.000 (extrap.)
280.1	0.737	$\Delta H = 9\ 910x$	

$BaI_2.2NH_3(s) = BaI_2(s) + 2NH_3(g)$ (656) (E)

T	P	T	P
336.1	0.021	351.1	0.071
349.7	0.066	$\Delta H = 26\ 800$	

$BaI_2.4NH_3(s) = BaI_2.2NH_3(s) + 2NH_3(g)$ (656) (E)

T	P	T	P
306.1	0.092	336.1	0.441
	$\Delta H = 22\ 600$		

$BaI_2.6NH_3(s) = BaI_2.4NH_3(s) + 2NH_3(g)$ (656) (E)

T	P	T	P
273.1	0.018	306.1	0.132
	$\Delta H = 22\ 200$		

$BaI_2.8NH_3(s) = BaI_2.6NH_3(s) + 2NH_3(g)$ (656) (E)

T	P	T	P
273.1	0.030	306.1	0.257
	$\Delta H = 21\ 400$		

$BaI_2.9NH_3(s) = BaI_2.8NH_3(s) + NH_3(g)$ (656) (E)

T	P	T	P
273.1	0.179	306.1	0.566
	$\Delta H = 10\ 000$		

$BaI_2.10\ NH_3(s) = BaI_2.9NH_3(s) + NH_3(g)$ (656) (E)

T	P	T	P
195.1	0.024	273.1	>1.111
	$\Delta H = 7\ 700$		

$Ba(NO_3)_2(aq)$

γ at 293.1°K (1188)

m	$-\log \gamma'$	γ'	θ*	$a_{(H_2O)}$
0.0005	0.0382	0.915	0.00271	0.999975
.001	.0536	.884	.00535	.999950
.002	.0741	.843	.01053	.999898
.005	.1133	.770	.02556	.999750
.01	.1541	.701	.04955	.999520
.02	.2074	.620	.09532	.999078
.05	.3002	.501	.22274	.997840
.1	.3898	.408	.41702	.995965
.2	.5030	.314	.76449	.992615

* θ = Freezing-point lowering, °C.

$BaCO_3(s) + H_2CO_3(aq) = Ba^{++} + 2HCO_3^-$

$K_{298.1} = 3.63 \times 10^{-5}$; $\Delta F^0_{298.1} = 6\ 060$ (1191, *from* (975)

$BaCO_3(s) + CO_2(g) + H_2O(l) = Ba^{++} + 2HCO_3^-$

Log $p.f._{289.1} = 1.952$; $K_{289.1} = 1.39 \times 10^{-6}$; $\Delta F^0_{289.1} = 7\ 752$; $K_{298.1} = 0.92 \times 10^{-6}$; $\Delta H = -7\ 860$; $\Delta F^0_{298.1} = 8\ 239$ (1191) *from* (975); $K_{298.1} = 1.22 \times 10^{-6}$; $\Delta F^0_{298.1} = 8\ 070$ (1191) *from* (1319)

$c_{(Ba^{++})}$	$c_{(HCO_3^-)}$	p_{CO_2}	f_{CO_2}	$\mu_c^{1/2}$	log $(1/K_c^{1/3})$
0.00601	0.001178	0.000504	0.000499	0.043	1.9257
.00732	.001444	.000808	.000800	.047	1.9063
.00117	.00232	.00333	.00333	.059	1.9064
.00196	.00392	.01387	.01373	.077	1.8862
.00255	.00510	.0282	.0279	.087	1.8747
.00312	.00624	.0499	.0495	.097	1.8700
.00464	.00928	.1417	.1403	.118	1.8485
.00578	.01156	.2529	.2504	.131	1.8369
.00690	.01380	.4217	.4175	.144	1.8341
.00766	.01532	.5529	.5474	.152	1.8279
.00843	.01686	.7292	.7220	.159	1.8263
.00941	.01882	.982	.973	.168	1.8217
.0137*	.0274	1.000	.990	.203	1.6611
.0299*	.0598	25.0	22.6	.299	1.7748

* Measurements by (564) at 291.1°K, expressed in molalities.

$BaCO_3(s) = BaO(s) + CO_2(g)$

$\Delta H = 62\ 200$, at room temperature; Hedvall (595) employing the not very accurate isothermal method, by the continued addition of heat, found $P = 1$ atmosphere at a temperature of 1634.1°K

$BaCO_3(s) + SO_4^{--} = BaSO_4(s) + CO_3^{--}$ (?)

$K_{298.1} = ca.\ 25$; $\Delta F^0_{298.1} = -1\ 908$; d_4^{25} given in original

$m_{(K_2SO_4)}$	$m_{(K_2CO_3)}$	μ	K_m
	$T = 298.1$°K		
0.00331	0.0690	0.217	20.9
.01218	.1873	.598	15.4
.0580(s)	.5243	1.747	9.03
	$T = 353.1$°K		
0.01178	0.0604	0.217	5.13
.02756	.1223	.450	4.49
.1704(s)	.4630	1.900	2.72
	$T = 373.1$°K		
0.01533	0.0571	0.217	3.73
.03639	.1131	.448	3.11
.2279(s)	.4144	1.927	1.82

$K_2SO_4(aq)$ and $K_2CO_3(aq)$ by $BaCl_2(aq)$; the solid phases may not be pure; $K_{298.1} = ca.\ 8$; $\Delta F^0_{298.1} = ca.\ -1\ 230$ (1167, 1168)

$c_{(K_2SO_4)}$	$c_{(K_2CO_3)}$	$c_{(KCl)}$	μ_c	K_c
		$T = 293.1$°K		
0.0005	0.0072	0.00068	0.0238	14.5
.0009	.0068	.00068	.0238	7.6
.0028	.0164	.0017	.0593	5.9

$BaCO_3(s) + SO_4^{--}$.—*(Continued)*

$c_{(K_2SO_4)}$	$c_{(K_2CO_3)}$	$c_{(KCl)}$	μ_c	K_c
		T = 293.1°K.—*(Continued)*		
0.0032	0.0160	0.0017	0.0593	5.0
.0147	.0619	.0068	.2366	4.2
.0159	.0607	.0068	.2366	3.8
.096	.287	.034	1.183	3.0
.104	.279	.034	1.183	2.7
		T = 369.1°K		
0.083	0.300	0.034	1.183	3.6
.089	.294	.034	1.183	3.3

$Ba(HCO_3)_2(s) = Ba^{++} + 2HCO_3^-$

$K_{298.1}$ = 2.50 × 10^{-5}; $\Delta F^0_{298.1}$ = 6 282 (1191) *from* (975); *cf.* (564)

$BaSiF_6(?) = BaF_2(?) + SiF_4(g)$ (1398) (E)

$\log P = -30\ 000/4.571T + 1.75 \log T + C$, where C is dependent upon n*

T	P	T	P
	n* = 0.16		
942.6	0.0687	1 009.1	0.4913
962.6	0.1170	1 020.1	0.7092
1 008.1	0.4803	1 042.6	1.464
	n* = 0.415		
960.1	0.0821	1 017.1	0.5039
995.1	0.2132	1 038.1	0.9280
1 008.1	0.3902	1 054.1	1.862
	n* = 1.23		
932.6	0.0162	1 005.1	0.1995
952.6	0.0379	1 014.6	0.2735
987.6	0.1200	1 043.6	0.6426
992.1	0.1364	1 049.6	0.7257

* $n = BaF_2/BaSiF_6$.

$BaCrO_4(s) + H^+ = Ba^{++} + HCrO_4^-$

In HCl(aq) at 291.1°K (71)		In HCl(aq) 310.1°K (71)	
$c_{(\Sigma H+)}$	$c_{(\Sigma Cr)}$	$c_{(\Sigma H+)}$	$c_{(\Sigma Cr)}$
0.2	0.0251	0.1	0.0202
.3	.0355	.2	.0367
.4	.0443	.3	.0535
.5	.0548	.4	.0702
.6	.0662	.5	.0875
		.6	.106

In HNO_3(aq) at 291.1°K (806)		In HNO_3(aq) 310.1°K (806)	
$c_{(\Sigma H+)}$	$c_{(\Sigma Cr)}$	$c_{(\Sigma H+)}$	$c_{(\Sigma Cr)}$
0.2	0.0251	0.1	0.0202
.3	.0355	.2	.0367
.4	.0443	.3	.0535
.5	.0548	.4	.0702
.6	.0662	.5	.0875
		.6	.106

$BaO.BaCO_3(s) = 2BaO(s) + CO_2(g)$ (423); *cf.* (10.5, 180, 667.5) (E)

T	P	T	P
1 293.1	0.0025	1 523.1	0.0893
1 393.1	0.0137	1 727.1*	0.987
	ΔH = 2 100		

* At higher temperatures the solid phase liquefies.

$2BaCO_3(s) = BaO.BaCO_3{}^*(s) + CO_2(g)$ (423) (E)

T	P	T	P
1 188.1	0.0005	1 293.1	0.0053
1 218.1	0.0011	1 318.1	0.0086
1 238.1	0.0016	1 343.1	0.0137
1 268.1	0.0032	1 368.1	0.0214
1 273.1	0.0036	1 373.1	0.0233

$2BaCO_3(s)$.—*(Continued)*

T	P	T	P
1 393.1	0.0330	1 528.1	0.272
1 418.1	0.0504	1 573.1	0.503
1 468.1	0.1116	1 623.1†	0.967
1 493.1	0.161	1 625.1	1.000
	ΔH = 63 200		

* The resulting $BaO.BaCO_3$ can dissolve BaO as well as $BaCO_3$. † At higher temperatures the basic carbonate exists as a fused mass. Pure $BaCO_3$ melts at 1623.1°K.

$3Ba(NH_2)_2(s) = Ba_3N_2(s) + 4NH_3(g)$ (794, 980)

Li, Lithium

Li(s); ΔH^0, ΔF^0 = 0

$Li(s) = Li^+ + E^-$

$E^0_{298.1}$ = 2.9578; $\Delta F^0_{298.1}$ = −68 248 (885) *from* (870)

$LiH(s) = Li(l) + \frac{1}{2}H_2(g)$ (394)

$LiOH(aq) = Li^+ + OH^-$ (780, 781)

$2LiOH(s) = Li_2O(s) + H_2O(g)$ (711, 717) (E)

ΔH (calc.) = 24 000; ΔH (Thomsen) = 24 000

T	P	T	P
793.1	0.003	1 038.1	0.259
823.1	0.009	1 055.1	0.309*
834.1	0.012*	1 085.1	0.424
867.1	0.0229*	1 099.1	0.467*
883.1	0.030	1 119.1	0.546
935.1	0.072*	1 148.1	0.692*
943.1	0.082	1 156.1	0.729
973.1	0.121*	1 176.1	0.856
997.1	0.159	1 197.1	1.000*
1 013.1	0.196*		

* Interpolated according to equation: $\log P = 3.9t_w + 530$, where t_w = the temperature at which the pressure of pure water is equal to the pressure of the LiOH at the measured temperature.

$LiCl.H_2O(s) = LiCl(s) + H_2O(g)$ (657, 658) (E)

T	P	T	P
303.1	0.0005	333.1	0.008
308.1	0.0010	338.1	0.0116
313.1	0.0016	343.1	0.0153–0.0174
318.1	0.0021	373.6	0.118*
323.1	0.0037	375.1†	0.132†
328.1	0.0050	ΔH = 14 630	

* Quadruple point. † Extrapolated from (657); all other values from (658).

$LiCl.2H_2O(s) = LiCl.H_2O(s) + H_2O(g)$ (657, 658) (E)

T	P	T	P
273.1	0.0005	285.6	0.003*
283.1	0.0016	338.1	0.132†
	ΔH = 13 700		

* Quadruple point. † Extrapolated from (657); all other values from (658).

$LiCl.3H_2O(s) = LiCl.2H_2O(s) + H_2O(g)$ (657, 658) (E)

T	P	T	P
238.1	0.0003	256.6	0.0010*
244.1	0.0004	331.1	0.132†
248.1	0.0004	ΔH = 13 600‡	

* Quadruple point. † Extrapolated from (657); all other values from (658).
‡ Calculated according to the Nernst equation.

$LiCl.NH_3(s) = LiCl(s) + NH_3(g)$ (100, 153) (E)

T	P	T	P
343.1	0.132*	382.3	0.850
361.1	0.337	392.1	1.283
369.1	0.483	ΔH = 12 400	

* Extrapolated from (100); all other values from (153).

$LiCl.2NH_3(s) = LiCl.NH_3(s) + NH_3(g)$ (100, 153) (E)

T	P	T	P
317.1	0.132*	356.1	0.972
341.9	0.491	372.3	1.289
350.1	0.734	ΔH = 11 500 (100)	

* Extrapolated from (100); all other values from (153).

$LiCl.3NH_3(s) = LiCl.2NH_3(s) + NH_3(g)$ (100, 153) (E)

T	P	T	P
296.6	0.132*	333.1	1.040
305.9	0.233	335.3	1.161
316.1	0.421	338.1	1.330
323.1	0.622	ΔH = 10 700 (100)	

* Extrapolated from (100); all other values from (153).

$LiCl.4NH_3(s) = LiCl.3NH_3(s) + NH_3(g)$ (100, 153) (E)

T	P	T	P
273.1	0.505	285.84	0.992
282.1	0.842	289.6	1.053
	ΔH = 8 800		

$LiCl.5NH_3(s) = LiCl.4NH_3(s) + NH_3(g)$ (100) (E)

T	P	T	P
214.6	0.0326	228.1	0.116
223.1	0.076	ΔH = 8 000	

$LiCl.CH_3NH_2(s) = LiCl(s) + CH_3NH_2(g)$ (153) (E)

T	P	T	P
339.3	0.664	347.5	1.077
344.1	0.845	ΔH = 13 800	

$LiCl.2CH_3NH_2(s) = LiCl.CH_3NH_2(s) + CH_3NH_2(g)$ (153) (E)

T	P	T	P
300.1	0.196	323.3	0.845
313.1	0.457	ΔH = 12 100	

$LiCl.3CH_3NH_2(s) = LiCl.2CH_3NH_2(s) + CH_3NH_2(g)$ (153) (E)

T	P	T	P
295.5	0.380	313.6	1.088
308.1	0.789	ΔH = 10 900	

$LiCl.C_2H_5NH_2(s) = LiCl(s) + C_2H_5NH_2(g)$ (153) (E)

T	P	T	P
362.4	0.996	364.8	1.129
	ΔH = 10 500		

$LiCl.2C_2H_5NH_2(s) = LiCl.C_2H_5NH_2(s) + C_2H_5NH_2(g)$ (153) (E)

T	P	T	P
342.5	0.978	345.1	1.105
	ΔH = 11 100		

$LiCl.3C_2H_5NH_2(s) = LiCl.2C_2H_5NH_2(s) + C_2H_5NH_2(g)$ (153) (E)

T	P	T	P
330.1	0.916	334.1	1.107
	ΔH = 10 500		

$LiClO_4.4NH_3(s) = (?) + xNH_3(g)$ (E)

P = 1.00 at room temperature (385)

$LiBr.H_2O(s) = LiBr(s) + H_2O(g)$ (657, 658) (E)

T	P	T	P
353.1	0.0024	413.1	0.132*
376.8	0.0122	432.1	0.300†
393.1	0.0343	ΔH = 17 250‡	

* From (657), all other values from (658). † Quadruple point. ‡ Calculated according to the Nernst equation.

$LiBr.2H_2O(s) = LiBr.H_2O(s) + H_2O(g)$ (657, 658) (E)

T	P	T	P
277.1	0.00018	301.1	0.0013
290.6–294.6	0.00079	303.1	0.0016
299.1	0.0010	305.1	0.0037†

$LiBr.2H_2O(s)$.—(*Continued*)

T	P	
359.1*	0.132	ΔH = 17 730‡

* From (657); all other values from (658). † Quadruple point. ‡ Calculated according to Nernst equation.

$LiBr.3H_2O(s) = LiBr.2H_2O(s) + H_2O(g)$ (E)

$P_{335.1} = 0.132$ (657)

$LiBr.NH_3(s) = LiBr(s) + NH_3(g)$ (100, 153) (E)

ΔH = 13 600 (100); 13 400 (153)

T	P	T	P
334.1	0.0138	368.6*	0.961
349.7	0.0349	370.6*	1.060
353.1	0.0428	372.1*	1.138†
365.1*	0.0826†	375.1	0.132†
366.1	0.0874	384.1	0.199

* From (153); all other values from (100); difficult to determine which are more accurate. † Extrapolated.

$LiBr.2NH_3(s) = LiBr.NH_3(s) + NH_3(g)$ (100, 153) (E)

T	P	T	P
321.1*	0.132†	363.6	1.115
358.1	0.862	365.1	1.216†
360.6	0.976†	ΔH = 11 800*	

* From (100); all other values from (153). † Extrapolated.

$LiBr.3NH_3(s) = LiBr.2NH_3(s) + NH_3(g)$ (100, 153) (E)

T	P	T	P
306.1*	0.132†	344.9	1.062
340.1	0.837	ΔH = 11 100*	

* From (100); all other values from (153). † Extrapolated.

$LiBr.4NH_3(s) = LiBr.3NH_3(s) + NH_3(g)$ (100, 153) (E)

T	P	T	P
293.1*	0.132†	331.1	1.000
327.1	0.812†	333.1	1.088
329.1	0.896	ΔH = 10 200*	

* From (100); all other values from (153). † Extrapolated.

$LiBr.5NH_3(s) = LiBr.4NH_3(s) + NH_3(g)$ (100) (E)

T	P	T	P
213.1	0.025	233.1	0.174
223.1	0.071	253.1	0.629
	ΔH = 8 050		

$LiBr.6\frac{1}{2}NH_3(s) = LiBr.5NH_3(s) + 1\frac{1}{2}NH_3(g)$ (100) (E)

T	P	T	P
194.6	0.047	213.1	0.207
	ΔH = 10 350		

$LiI.\frac{1}{2}H_2O(s) = LiI(s) + \frac{1}{2}H_2O(g)$ (E)

$P_{486.1} = 0.132$; ΔH = 10 200 (657)

$LiI.H_2O(s) = LiI.\frac{1}{2}H_2O(s) + \frac{1}{2}H_2O(g)$ (657) (E)

T	P	T	P
<403.1	0.0086*	451.1	0.132
	ΔH = 9 500		

* Quadruple point.

$LiI.2H_2O(s) = LiI.H_2O(s) + H_2O(g)$ (657) (E)

T	P	T	P
350.1	0.0059*	401.1	0.132 (extrap.)
	ΔH = 16 800		

* Quadruple point.

$LiI.3H_2O(s) = LiI.2H_2O(s) + H_2O(g)$ (657) (E)

T	P	T	P
343.6	0.009*	385.1	0.132 (extrap.)
	ΔH = 16 000		

* Quadruple point.

LiI.SO$_2$(s) = (?) + xSO$_2$(g) (392) (E)

T	P	T	P
261.1	0.329	273.1	0.592
263.6	0.362	281.1	1.000 (extrap.)
265.6	0.382	ΔH = 9 740x	

LiI.2SO$_2$(s) = (?) + xSO$_2$(g) (392) (E)

T	P	T	P
252.6	0.355	265.6	0.671
259.1	0.500	272.1	1.000 (extrap.)
261.6	0.553	ΔH = 9 400x	

LiI.NH$_3$(s) = LiI(s) + NH$_3$(g) (100) (E)

T	P	T	P
388.1	0.0112	408.1	0.0309
398.1	0.0195	ΔH = 16 000	

LiI.2NH$_3$(s) = LiI.NH$_3$(s) + NH$_3$(g) (100) (E)

T	P	T	P
337.9	0.0132	363.1	0.054
351.3	0.0276	373.1	0.0821
353.1	0.0320	ΔH = 13 800	

LiI.3NH$_3$(s) = LiI.2NH$_3$(s) + NH$_3$(g) (100) (E)

T	P	T	P
291.1	0.0068	329.1	0.0864
307.6	0.0221	337.9	0.140
319.1	0.0509	ΔH = 12 200	

LiI.4NH$_3$*(s) = LiI.3NH$_3$(s) + NH$_3$(g) (100, 385) (E)

T	P	T†	P†
288.1†	0.008	338.1	0.214
307.6	0.030	348.1	0.408
319.1	0.061	356.1	0.638
329.1	0.103	360.1	0.804
334.6	0.133	363.1	0.979
337.9	0.159	ΔH = 11 600 (100)	

* According to (385) LiI.4NH$_3$ exists in an unstable form for which P = 0.434 at T = 230.1°K. † From (385); all other values from (100).

LiI.5NH$_3$(s) = LiI.4NH$_3$(s) + NH$_3$(g) (100) (E)

T	P	T	P
203.1	0.009	233.1	0.159
213.1	0.0266	253.1	0.661
223.1	0.067	ΔH = 8 300	

LiI.5½NH$_3$(s) = LiI.5NH$_3$(s) + ½NH$_3$(g) (100) (E)

T	P	T	P
194.6	0.033	213.1	0.162
203.1	0.071	ΔH = 3 600	

LiI.7NH$_3$(s) = LiI.5½NH$_3$(s) + 1½NH$_3$(g) (100) (E)

T	P	T	P
194.6	0.0386	213.1	0.197
203.1	0.092	ΔH = 10 650	

LiC$_2$H$_3$O$_2$.C$_2$H$_4$O$_2$(s) = LiC$_2$H$_3$O$_2$(s) + C$_2$H$_4$O$_2$(g) (846) (E)

T	P	T	P
353.1	0.046	373.1	0.197

Li$_2$SO$_4$.H$_2$O(s) = Li$_2$SO$_4$(s) + H$_2$O(g) (848) (E)

T	P	T	P
333.1	0.029	373.1	0.242
353.1	0.080	381.1	0.347

Li$_2$CO$_3$(s) = Li$_2$O(s) + CO$_2$(g) (717, 837) (E)

T	P	T	P
883.1*	0.0013	913.1	0.011
883.1	0.0013	983.1	0.021
893.1	0.004	996.1*	0.005

Li$_2$CO$_3$(s).—*(Continued)*

T	P	T	P
1 013.1	0.025	1 161.1*	0.042
1 043.1	0.030	1 163.1	0.067
1 058.1*	0.013	1 183.1*	0.054
1 073.1	0.038	1 203.1	0.080
1 083.1*	0.020	1 235.1*	0.083
1 103.1	0.045	1 273.1	0.120
1 113.1	0.049	1 283.1*	0.131
1 133.1	0.054	1 473.1	0.395
1 133.1*	0.029		

* From (717); all other values from (837); difficult to determine which are more accurate.

Li$_2$SiF$_6$ (s) = LiF (?) + SiF$_4$(g) (1398) (E)

$$\log P = -25\ 200/4.571T + 1.75 \log T + 0.01306T - 0.041766T^2 + 0.319$$

T	P	T	P
753.1	0.0399	836.1	0.9510
775.1	0.1104	844.1	1.036
791.1	0.2203	848.1	1.3037
812.1	0.3646	862.1	1.789
824.1	0.6713		

Na, Sodium

Na(s) ; ΔH^0, ΔF^0 = 0

Na(s) = Na$^+$ + E$^-$

$E^0_{298.1}$ = 2.7125; $\Delta F^0_{298.1}$ = −62 588 (885) *from* (15, 1910)

Na(s) = Na (in amalg.)

%Na = 0.206, $E_{298.1}$ = 0.8453 (1910); *cf.* (1217)

NaH(s) = Na(g) + ½H$_2$(g)

$\log p = -5\ 700/T - 2.5 \log T + 1.075$ (759)

NaOH (lowest hydrate) = NaOH(s) + xH$_2$O(g) (69) (E)

T	P	T	P
273.1	0.00005	323.1	0.00151
298.1	0.00020		

NaCl(s) ; $\Delta F^0_{298.1}$ = −91 792 (885) *from* (15)

NaCl.5NH$_3$(s) = NaCl(s) + 5NH$_3$(g) (100) (E)

T	P	T	P
194.6	0.0094	223.1	0.145
213.1	0.053	249.1	1.022
	ΔH = 39 000		

NaBr.2H$_2$O(s) = NaBr(s) + 2H$_2$O(g) (211, 844); *cf.* (1325) (E)

T	P	T	P
283.1	0.0045	293.1	0.01007
293.1*	0.00720	303.1	0.0204

* From (211); all other values from (844).

NaBr.5¼NH$_3$(s) = NaBr(s) + 5¼NH$_3$(g) (100) (E)

T	P	T	P
213.1	0.0108	233.1	0.0695
218.1	0.0179	243.1	0.158
	ΔH = 44 360		

NaBr.5¾NH$_3$(s) = NaBr.5¼NH$_3$(s) + ½NH$_3$(g) (100) (E)

T	P	T	P
194.6	0.047	203.1	0.0953
	ΔH = 3 475		

$NaI.2H_2O(s) = NaI(s) + 2H_2O(g)$ (526, 847) (E)

T	P	T	P
294.96*	0.00287	313.1	0.0118
302.90*	0.00514	323.1	0.022
303.1	0.0057	333.1	0.037
311.86*	0.00972		

* From (526); all other values from (847).

$NaI.2SO_2(s) = (?) + xSO_2(g)$ (392) (E)

T	P	T	P
253.1	0.096	276.1	0.500
261.6	0.145	280.1	0.629
265.6	0.237	284.6	0.809
268.1	0.276	288.1	0.987
273.1	0.404	ΔH = 10 010x	

$NaI.4SO_2(s) = (?) + xSO_2(g)$ (392) (E)

T	P	T	P
271.1	0.671	278.1	1.000 (extrap.)
273.1	0.763	ΔH = 9 650x	

$NaI.4\frac{1}{2}NH_3(s) = NaI(s) + 4\frac{1}{2}NH_3(g)$ (100) (E)

T	P	T	P
233.1	0.0084	263.1	0.0770
243.1	0.0172	273.1	0.162
253.1	0.0375	ΔH = 42 300	

$NaI.6NH_3(s) = NaI.4\frac{1}{2}NH_3(s) + 1\frac{1}{2}NH_3(g)$ (100) (E)

T	P	T	P
195.1	0.014	208.1	0.0522
200.1	0.024	213.1	0.078
203.1	0.0321	218.1	0.113
	ΔH = 11 250		

$NaHC_2O_4.3H_2O(s) = NaHC_2O_4(s) + 3H_2O(g)$ (66) (E)

$\log P = 16.7013 - 11\,042.9/(T + 290.1)$

T	P	T	P
248.1	0.00014	293.1	0.00579
258.1	0.00036	298.1	0.00841
273.1	0.00118	303.1	0.01209
278.1	0.00183	308.1	0.01730
283.1	0.00271	313.1	0.02461
288.1	0.00399	323.1	0.04895
	ΔH = 26 040 (Thomsen)		

$NaC_2H_3O_2.1\frac{1}{2}H_2O(s) = (?) + xH_2O(g)$ (843) (E)

T	P	T	P
288.1	0.00270	303.1	0.0091
293.1	0.0047	308.1	0.0138

$NaC_2H_3O_2.3H_2O(s) = NaC_2H_3O_2(s) + 3H_2O(g)$; *cf.* (1325) (E)

$NaC_2H_3O_2.3H_2O(s) = NaC_2H_3O_2.1\frac{1}{2}H_2O(s) + 1\frac{1}{2}H_2O(g)$ (843); *cf.* (1033)

T	P	T	P
288.1	0.0032	308.1	0.0201
293.1	0.0058	313.1	0.0271
298.1	0.0091	323.1	0.0464
303.1	0.0138		

$NaC_2H_3O_2.C_2H_4O_2(s) = NaC_2H_3O_2(s) + C_2H_4O_2(g)$ (846) (E)

T	P	T	P
393.1	0.082	413.1	0.171
403.1	0.125	423.1	0.292

$NaC_2H_3O_2.2C_2H_4O_2(s) = NaC_2H_3O_2.C_2H_4O_2(s) + C_2H_4O_2(g)$ (E)

$P_{348.1} = 0.145$ (846)

$NaC_2Cl_3O_2.C_2H_4O_2(s) = NaC_2Cl_3O_2(s) + C_2H_4O_2(g)$ (E)

$P_{403.1} = 0.500$; if the content of $C_2H_4O_2$ falls to 0.27 mole, the pressure falls to 0.395 atm. (846)

$2PbCO_3(s) + Na^+ + CO_3^{--} + H_2O(l) = NaPb_2(CO_3)_2OH(s) + HCO_3^-$

$K_{291.1} > 12$ (36)

$3NaPb_2(CO_3)_2OH(s) + H_2O(l) = 2(2PbCO_3.PbOH)(s) + 3Na^+ + CO_3^{--} + HCO_3^-$

$\sqrt[5]{K_{291.1}} < 0.05$ (36)

$NaPb_2(CO_3)_2OH(s) + CrO_4^{--} = PbCrO_4.PbO(s) + CO_3^{--} + HCO_3^- + Na^+$

$K_{291.1} = ca.\ 6.6$ (36)

$NaCr(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (399) (E)

T	P	T	P
324.1	0.057	349.1	0.213
336.1	0.109	353.1	0.317
344.1	0.161	363.1	0.503

$NaAl(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (851); *cf.* (1033) (E)

T	P	T	P
304.1	0.026	328.1	0.133
315.1	0.064	332.1	0.164
323.1	0.103		

$Na_2SO_4(aq)$

γ at 273.1°K (1188)

m	$-\log \gamma'$	γ'	θ*	$a_{(H_2O)}$
0.0005	0.0365	0.920	0.00271	0.999975
.001	.0507	.890	.00536	.999950
.002	.0701	.851	.01057	.999895
.005	.1060	.783	.02574	.999748
.01	.1433	.719	.05013	.999515
.02	.1903	.645	.09706	.999060
.05	.2701	.537	.22978	.997775
.1	.3482	.449	.43551	.995787
.2	.4276	.374	.85767	.991715

* θ = Freezing-point lowering, °C.

$Na_2SO_4.7H_2O(s) = Na_2SO_4(s) + 7H_2O(g)$ (1389, 1557); *cf.* (843, 844) (E)

T	P	T	P
293.1*	0.0174	296.7	0.0232
294.1	0.0188	297.0	0.0237
295.1	0.0203	297.2	0.0241
296.0	0.0218	297.5	0.0249

* From (1389); all other values from (1557).

$Na_2SO_4.10H_2O(s) = Na_2SO_4(s) + 10H_2O(g)$ (66, 68, 843, 844, 1335, 1389, 1531, 1557); *cf.* (437, 1033) (E)

ΔH = 188 000 (Berthelot); = 192 600 (Thomsen); = 244 000 (1557) calculated from van't Hoff equation; $\log P = 7.685 - 2794.1/(T + 3)$ (68)

T	P	T	P
273.1*	0.00368	294.7	0.0186
273.1†	0.0050	296.1	0.0207
278.1†	0.00684	297.2	0.0224
282.1	0.00689	298.1‡	0.02526
283.1†	0.0092	298.1§	0.02521
288.1†	0.01276	298.1‖	0.02529
293.1*	0.01743	298.1	0.0238
293.1†	0.0183	298.1†	0.0250
293.1	0.0164	299.0	0.0255

$Na_2SO_4.10H_2O(s)$.—(*Continued*)

T	P	T	P
300.1	0.0276	302.6	0.0329
301.2	0.0299	304.1	0.0367
302.1†	0.0316	305.5	0.0405¶

* From (66). † From (843, 844). ‡ From (68). § From (1335). ‖ From (1557); all other values from (1389). ¶ Transition point.

$Na_2S_2O_3.5H_2O(s) = Na_2S_2O_3(s) + 5H_2O(g)$ (849); *cf.* (1032, 1325) (E)

T	P	T	P
288.1	0.0037	308.1	0.0154
293.1	0.0054	313.1	0.0238

$Na_2HPO_4.2H_2O(s) = Na_2HPO_4(s) + 2H_2O(g)$ (437, 1090); *cf.* (1030, 1325) (E)

T (437)	P	T (1090)	P
298.1	0.0117	298.1	0.0128

$Na_2HPO_4.7H_2O(s) = Na_2HPO_4.2H_2O(s) + 5H_2O(g)$ (437, 843, 1031, 1531); *cf.* (1030, 1325) (E)

T	P	T	P
273.1	0.0024	305.7*	0.0250
278.1	0.0036	308.1	0.0342
283.1	0.0051	313.1	0.0507
288.1	0.0075	329.2*	0.1042
290.6*	0.00837	330.9*	0.1146
293.1	0.01065	332.3*	0.1134
298.1	0.0157	333.1	0.149
298.1†	0.0163	333.2*	0.1229
298.1‡	0.01909	334.9*	0.1341
299.35*	0.0167	353.1	0.3579
299.7*	0.0176	372.1	0.784
303.1	0.0237		

* From (1031). † From (437). ‡ From (1531); all other values from (843).

$Na_2HPO_4.12H_2O(s) = Na_2HPO_4.7H_2O(s) + 5H_2O(g)$ (66, 437, 458, 1531); *cf.* (843, 844, 1030, 1031) (E)

ΔH = 56 100 (Thomsen); = 112 200 (458); *cf.* (1325)

T	P	T	P
248.1	0.00037*	293.25†	0.01717
258.1	0.00095*	296.12†	0.02130
273.1	0.00350	298.1	0.00754
278.1	0.00530*	298.1‡	0.02517
279.90†	0.00607	298.1§	0.0237
283.1	0.00793*	300.10†	0.02840
283.92†	0.00839	303.1	0.01063
288.1	0.01175	308.1	0.01491
288.10†	0.01163	313.1	0.02076
290.38†	0.01385	323.1	0.03967
293.1	0.00532*		

* Calculated according to equation: $\log P = 11.2764 - 5\,172/(T + 103.63)$. † From (458). ‡ From (1531). § From (437); all other values from (66).

$Na_2HAsO_4.12H_2O(s) = Na_2HAsO_4.7H_2O(s) + 5H_2O(g)$ (843, 1114) (E)

T	P	T	P
273.1	0.0013	303.1*	0.02006
278.1	0.0016	308.1*	0.02729
283.1	0.0028	313.1	0.0382
288.1	0.0045	333.1	0.101
293.1	0.0061	343.1	0.149
298.1	0.0129	353.1	0.247
298.1*	0.01461	373.1	0.558
303.1	0.0197	ΔH^* = 4 650 for $H_2O(l)$	

* From (1114); all other values from (843)

Lescoeur (843) ascribes the above values to the 7-hydrate. He gives the following values for the change from the 12-hydrate to 7-hydrate:

T	P	T	P
273.1	0.0041	288.1	0.0151
278.1	0.0059	293.1	0.0211
283.1	0.0099		

$Na_2CO_3(l) + 4C\ (graph.) + N_2(g) = 2NaCN(l) + 3CO(g)$ (416, 665)

$Na_2CO_3(s) = Na_2O(s) + CO_2(g)$ (837, 717) (E)

T	P	T	P
933.1*	0.0022	1 263.1	0.016
973.1	0.0013	1 283.1	0.018
1 003.1	0.0020	1 323.1	0.021
1 038.1*	0.0038	1 353.1	0.025
1 093.1	0.0039	1 373.1	0.028
1 130.1*	0.0051	1 423.1	0.037
1 153.1	0.013	1 453.1	0.050
1 193.1*	0.0061	1 473.1	0.054
1 248.1*	0.0075		

* From (717); all other values from (837); difficult to determine which are more accurate.

$2NaHCO_3(s) = Na_2CO_3(s) + H_2O(g) + CO_2(g)$ (266) (E)

$\log P = 8.9377 - 3\,340/T$

T	P	T	P
303.1	0.0082	373.1	0.9620
323.1	0.0395	380.5	1.4501
343.1	0.1584	383.1	1.6481
363.1	0.5451	384.8	1.8410
365.5	0.6151	388.6	2.1772

$Na_2CO_3.H_2O(s) = Na_2CO_3(s) + H_2O(g)$ (226, 843) (E)

$\Delta H = 13\,800$; $\log P = 7.944 - 3000.0/T$

T	P	T	P
293.1*	0.0047	349.5	0.2192
303.6	0.0104	353.4	0.2843
313.5	0.0209	356.2	0.3202
324.1	0.0482	359.5	0.3909
330.2	0.0705	363.4	0.4781
339.5	0.1226	365.8	0.5525
343.2	0.1601	370.8	0.7093

* From (843); all other values from (266).

$Na_2CO_3.10H_2O(s) = Na_2CO_3.7H_2O(s) + 3H_2O(g)$ (66); *cf.* (843) (E)

T	P	T	P
248.1	0.00038*	288.1	0.01146
258.1	0.00097*	293.1	0.01656*
273.1	0.00350	298.1	0.02369
278.1	0.00530*	305.12	0.03850*
283.1	0.00784*	ΔH = 16 470 (Thomsen)	

* Calculated according to equation: $\log P = 7.9263 - 3\,634.51/(T + 46.45)$.

$Na_2C_4H_4O_6.2H_2O(s) = (?) + xH_2O(g)$ (918) (E)

T	P	T	P
282.2	0.0099	303.1	0.0367*
285.8	0.0126	308.1	0.0488*
288.1	0.0145*	310.6	0.0563
290.3	0.0164	313.1	0.0643*
293.1	0.0200*	314.1	0.0688
295.1	0.0228	317.7	0.0820
296.6	0.0245	321.7	0.0995
298.1	0.0272*		

* Interpolated according to equation: $t = 1.00t_w + 2.3$, where t_w = the temperature at which water has the same pressure as the compound at the temperature, t.

$n\mathrm{Na_2SiF_6}(?) = m\mathrm{NaF}(?) + \mathrm{SiF_4}(g)$ (1398) (E)

n = moles Na_2SiF_6, m = moles NaF in solid phase; $\log P = -30\ 600/4.571T + 1.75 \log T - 0.001823T + 0.319$

T	P	T	P
$n = 0.976$; $m = 0.024$		$n = 0.776$; $m = 0.224$	
989.1	0.0039	1 049.1	0.0136
1 098.1	0.0509	1 103.1	0.0517
1 202.1	0.3173	1 199.1	0.3177
1 225.1	0.4609	1 251.1	0.6110
$n = 0.511$; $m = 0.489$		$n = 0.330$; $m = 0.670$	
1 105.1	0.0559	1 171.1	0.1873
1 197.1	0.2842	1 234.1	0.5207
1 248.6	0.6137	1 251.6	0.6634
1 277.1	0.8405	1 320.1	1.1148
1 310.1	1.415	1 380.1	1.485
$n = 0.092$; $m = 0.908$			
1 158.1	0.1482	1 291.1	0.9044
1 220.1	0.4011	1 343.1	1.2601
1 256.1	0.6772		

$\mathrm{Na_2B_4O_7.5H_2O}(s) = (?) + x\mathrm{H_2O}(g)$ (849) (E)

T	P	T	P
333.1	0.040	338.1	0.059

$\mathrm{Na_2B_4O_7.10H_2O}(s) = \mathrm{Na_2B_4O_7.5H_2O}(s) + 5\mathrm{H_2O}(g)$ (E)

$P_{293.1} = 0.01145$ (849)

$\mathrm{NaNO_3.CaS_2O_3.Na_2S_2O_3.11H_2O}(s) = \mathrm{NaNO_3.CaS_2O_3.6H_2O}(s) + \mathrm{Na_2S_2O_3.5H_2O}(s)$

$\Delta F^0_{302.2} = 0$ (795.5)

$\mathrm{Na_3[Fe(C_2O_4)_3].3H_2O}(s) = \mathrm{Na_3[Fe(C_2O_4)_3]}(s) + 3\mathrm{H_2O}(g)$ (E)

$P_{298.1} = 0.0003 - 0.0008$ (916)

$\mathrm{Na_3[Fe(C_2O_4)_3].9H_2O}(s) = \mathrm{Na_3[Fe(C_2O_4)_3].3H_2O}(s) + 6\mathrm{H_2O}(g)$ (E)

$P_{298.1} = 0.0116 - 0.0176$ (916)

$\mathrm{Na_3(NH_4)_3[Fe(C_2O_4)_3]_2.7H_2O}(s) = (?) + x\mathrm{H_2O}(g)$ (916) (E)

The first two molecules of water are lost continuously while the crystals remain clear. The next four molecules are evolved discontinuously and the crystals are turbid; over H_2SO_4 at 298.1°K

P_{H_2O}	Loss H_2O, Moles	P_{H_2O}	Loss H_2O, Moles
0.02579	0.00	0.01161	0.97
0.02139	0.18	0.00593	2.00
0.01769	0.48	0.00230 to 0.00	5.98

$\mathrm{Na_3(NH_4)_3.[Al(C_2O_4)_3]_2.7H_2O}(s) = (?) + x\mathrm{H_2O}(g)$ (916) (E)

The first two moles of H_2O escape continuously, the crystals remaining clear; the next four moles escape while the crystals are turbid; over H_2SO_4 soln.

$\%H_2SO_4$	Loss H_2O, Moles	
	283.1°K	296.1°K
10	Deliquescent	Deliquescent
20	0	Deliquescent
30	0.18	0
40	0.30	0.16
50	0.57	0.43
60	1.98	1.62
70	6.00	1.96
80	6.01	5.96
90	6.01	5.96
97	6.01	5.96

K, Potassium

$\mathrm{K}(s)$; ΔH^0, $\Delta F^0 = 0$

$\mathrm{K.NH_3}(s) = \mathrm{K}(s) + \mathrm{NH_3}(g)$ (706) (E)

$\mathrm{K}(s) = \mathrm{K^+} + \mathrm{E^-}$

$E^0_{298.1} = 2.2924$; $\Delta F^0_{298.1} = -67\ 431$ (885) *from* (869)

$\mathrm{KH}(s) = \mathrm{K}(l) + \frac{1}{2}\mathrm{H_2}(g)$

$\log p = -5\ 850/T + 2.6 \log T + 1.014$ (759)

KOH (lowest hydrate) $= \mathrm{KOH}(s) + x\mathrm{H_2O}(g)$ (E)

$P_{323.1} = 0.000009$ (69)

$\mathrm{KOH.\frac{1}{2}H_2O}(s) = \mathrm{KOH}(s) + \frac{1}{2}\mathrm{H_2O}(g)$ (E)

$P_{303.1} = 0.00$ (148)

$\mathrm{KOH.\frac{3}{4}H_2O}(s) = \mathrm{KOH.\frac{1}{2}H_2O}(s) + \frac{1}{4}\mathrm{H_2O}(g)$ (E)

$P_{304.85} = 0.00097$ (148)

$\mathrm{KOH.H_2O}^*(s) = \mathrm{KOH.\frac{3}{4}H_2O}(s) + \frac{1}{4}\mathrm{H_2O}(g)$ (148) (E)

T	P	T	P
300.85	0.0020	314.85	0.00275

* $KOH.H_2O$ dissolves $KOH.\frac{3}{4}H_2O$ in very small amounts, therefore the dissociation pressure does not diminish abruptly at the transition point, but diminishes continuously over a very small interval. The same holds for $KOH.\frac{3}{4}H_2O$, which can absorb $KOH.\frac{1}{2}H_2O$ in small amounts.

$\mathrm{KOH.2H_2O}(s) = \mathrm{KOH.H_2O}(s) + \mathrm{H_2O}(g)$ (E)

$P_{300.85} = 0.00475$ (148)

$\mathrm{KCl}(aq)$ (1193)

m	$\gamma_{293.1}$	m	$\gamma_{293.1}$
0.1	0.772	1.0	0.601
.2	.715	2.0	.570
.5	.651		

$\mathrm{KClO_3}(s)$; $\Delta F^0_{298.1} = -69\ 250$ (885)

$\mathrm{KBr.4NH_3}(s) = \mathrm{KBr}(s) + 4\mathrm{NH_3}(g)$ (100) (E)

T	P	T	P
194.6	0.0366	213.1	0.179
208.1	0.120	$\Delta H =$	28 600

$\mathrm{KICl_2}(s) = (?)$ (382) (E)

T	P	T	P
314.1	0.037	375.1	0.384
331.1	0.076	385.1	0.509
344.6	0.150	395.1	0.664
352.6	0.201	404.1	0.816
363.1	0.276	409.1	0.926

$\mathrm{KIBr_2}(s) = (?)$ (382) (E)

T	P	T	P
290.1	0.007	344.1	0.129
313.1	0.020	353.1	0.184
327.6	0.062		

$\mathrm{KI.4SO_2}(s) = (?) + x\mathrm{SO_2}(g)$ (392, 1487) (E)

T	P	T	P
252.1	0.146	274.6	0.680
261.1	0.184	278.1	0.796
273.1	0.649	278.6	0.836
273.36*	0.657	279.6	0.895
	$\Delta H = 9\ 670x$		

* From (1487); all other values from (392).

$\mathrm{KI.4NH_3}(s) = \mathrm{KI}(s) + 4\mathrm{NH_3}(g)$ (100) (E)

T	P	T	P
186.1	0.010	213.1	0.0467
203.1	0.0195	218.1	0.070
208.1	0.0309	$\Delta H = 30\ 600$	

$\mathrm{KI.6NH_3}(s) = \mathrm{KI.4NH_3}(s) + 2\mathrm{NH_3}(g)$ (100) (E)

T	P	T	P
194.6	0.020	203.1	0.397
	$\Delta H = 14\ 700$		

KCN(s) = $K^+ + CN^-$; $\Delta F^0_{298.1} = -2\ 130$ (885) *from* (863)

KCNO(s) = $K^+ + CNO^-$; $\Delta F^0_{298.1} = -1\ 440$ (885) *from* (863)

KCNO(s) + CO = KCN(s) + CO_2

$K_{555.1} = 0.89$; $\Delta F^0_{555.1} = 128$ (863); $\Delta F^0_{298.1} = 2\ 060$ (885)

KCNO(l, with 14.6% KCN) + CO(g) = KCN(l, with 85.4% KCNO) + CO_2(g) (863)

T	*K*	*T*	*K*
721	(1.86)	816	2.22
724	(1.92)	823	2.28
770	1.98	840	2.35
774	1.98	840	2.29
776	1.97	841	2.26
778	2.03	846	2.46
780	2.06	847	2.33
781	1.99		

KCNS.½SO_2(s) = (?) + xSO_2(g) (392) (E)

T	*P*	*T*	*P*
273.1	0.033	312.6	0.526
282.6	0.071	314.9	0.654
283.6	0.079	320.1	0.912
286.6	0.103	322.1	0.980
296.1	0.195	$\Delta H = 11\ 310x$	

KCNS.SO_2(s) = (?) + xSO_2(g) (392) (E)

T	*P*	*T*	*P*
252.1	0.112	279.6	0.678
273.1	0.470	285.1	0.993
278.1	0.632	286.1	1.026
	$\Delta H = 9\ 910x$		

$KC_2H_3O_2.C_2H_4O_2$(s) = $KC_2H_3O_2$(s) + $C_2H_4O_2$(g) (846) (E)

T	*P*	*T*	*P*
433.1	0.016	453.1	0.092
443.1	0.042		

$KC_2H_3O_2.2C_2H_4O_2$(s) = $KC_2H_3O_2.C_2H_4O_2$(s) + $C_2H_4O_2$(g) (846) (E)

T	*P*	*T*	*P*
333.1	0.079	373.1	0.171
353.1	0.132		

$KCr(SO_4)_2.12H_2O$(s) = (?) + xH_2O(g) (399, 851) (E)

T	*P*	*T*	*P*
283.1*	0.0049	323.1	0.083
288.1*	0.0079	328.1	0.113
293.1*	0.0120	333.1	0.157
298.1*	0.0162	339.1	0.222
303.1*	0.0220	343.1	0.266
304.1	0.020	346.1	0.295
308.1*	0.0313	352.1	0.342
313.1	0.041		

* From (851); all other values from (399).

$KAl(SO_4)_2.3H_2O$(s) = (?) + xH_2O(g) (851); *cf.* (1033) (E)

T	*P*	*T*	*P*
303.1	0.0013	373.1	0.167
343.1	0.036	388.1	0.421
363.1	0.111		

$KAl(SO_4)_2.12H_2O$(s) = (?)* + xH_2O(g) (146, 399, 851); *cf.* (1033) (E)

T	*P*	*T*	*P*
293.1	0.0061	316.1†	0.0201
303.1	0.00849	323.1‡	0.024
306.1†	0.0114	328.1	0.0953
330.1†	0.0529	343.1‡	0.136
333.1‡	0.067	343.1	0.163
333.1	0.129	348.1	0.276
338.1	0.168	350.1†	0.2198
340.1	0.1116	353.1‡	0.263

* According to (851) and (1033) the decomposition goes to the trihydrate; (146), however, found at 3.2 moles H_2O, $P = 0.1356$ at $T = 350.1$; (399) found for 9 moles H_2O, that the vapor pressure diminished only a little; *e.g.*, $P = 0.057$ at $T = 333.1$, and $P = 0.232$ at $T = 353.1$.

† From (146). ‡ From (399); all other values from (851).

$KFe(SO_4)_2.12H_2O$ and $KAl(SO_4)_2.12H_2O$ (mixed crystals) = (?)* + xH_2O(g) (641) (E)

Mole % Fe-alum	*P* at *T* = 293.1 ± 0.2	Mole % Fe-alum	*P* at *T* = 293.1 ± 0.2
0.0	0.0026	62.4	0.0086
4.0	0.0022	71.8	0.0106
7.8	0.0020	78.1	0.0103
15.2	0.0018	89.0	0.0106
24.6	0.0021	98.2	0.0130
39.3	0.0028	100.0	0.0143
54.9	0.0051		

* From the maximum in the vapor-pressure curve Hollman deduces a compound containing 2 moles Fe-alum and 1 mole of Al-alum.

$KCr(SO_4)_2.12H_2O$ and $KAl(SO_4)_2.12H_2O$ (mixed crystals) = (?)* + xH_2O(g) (641) (E)

Mole % Cr-alum	*P* at *T* = 293.1 ± 0.2	Mole % Cr-alum	*P* at *T* = 293.1 ± 0.2
0.0	0.0026	63.2	0.0071
2.3	0.0022	71.8	0.0088
17.2	0.0020	78.8	0.0077
28.9	0.0020	87.4	0.0089
41.1	0.0026	95.3	0.0134
53.3	0.0044	100.0	0.0174

* Hollman deduces a compound of 2 moles Cr-alum to 1 mole of Al-alum.

$BeK(SO_4)_2$(s) = (?) + SO_2(g) + O_2(g) (951)

$KMgCl_3.6H_2O$(s) = (?) + xH_2O(g) (E)

$P_{305.45} = 0.0013$ (148)

$MgK(SO_4)_2$(s) = (?) + SO_2(g) + O_2(g) (951)

$MgSO_4.KCl.3H_2O$(s) = (?) + xH_2O(g) (E)

$P_{305.45} = 0.0013$ (148)

$NaKC_4H_4O_6.4H_2O$(s) = (?) + xH_2O(g) (918) (E)

T	*P*	*T*	*P*
288.1	0.0054*	302.8	0.0176
291.1	0.0072	303.1	0.0178*
293.1	0.0083*	303.2	0.0180
294.5	0.0093	308.1	0.0253*
297.1	0.0113	308.2	0.0258
298.1	0.0122*	313.1	0.0366*
298.2	0.0122		

* Interpolated according to equation: $t = 0.881t_w + 16.0$.

$2KHF_2$(l, in satd. $(KF)_2HF$) = $(KF)_2HF$(l, in satd. KF) + HF(g)

Upper phase KHF_2 with slight excess of KF, lower phase approx. $(KF)_2HF$. Compositions remain constant (1018)

T	*P*	*T*	*P*
503.6	0.0659	531.6	0.1045
506.1	.0654	539.1	.1269
515.1	.0828	554.1	.1581
521.1	.0814	567.1	.2198
526.6	.0953	610.6	.3480
530.1	.0993		

$2KHCO_3(s) = K_2CO_3(s) + CO_2(g) + H_2O(g)$ (266) (E)

$\log P = 7.951 - 3\,420/T$

T	P	T	P
340.8	0.0054	411.5	0.4247
349.4	0.0150	419.4	0.6203
363.3	0.0324	420.9	0.6620
365.6	0.0411	424.9	0.8034
376.6	0.0759	426.5	0.8725
389.5	0.1463	428.5	0.9392
392.2	0.1633	429.1	0.9645
400.3	0.2527		

$K_2CO_3(s) = K_2O(s) + CO_2(g)$ (837)

T	P	T	P
1 003.1	0.000	1 233.1	0.007
1 063.1	0.0007	1 243.1	0.012
1 083.1	0.0013	1 273.1	0.016
1 163.1	0.004	1 363.1	0.022

$K_2CO_3.1\frac{1}{2}H_2O(s) = K_2CO_3(s) + 1\frac{1}{2}H_2O(g)$ (E)

$P_{298.1} = 0.0014$ (430)

$K_2CO_3.2H_2O(s) = K_2CO_3(s) + 2H_2O(g)$ (849) (E)

T	P	T	P
363.1	0.075	383.1	0.226
373.1	0.132	393.1	0.362

$K_2CO_3.2H_2O(s) + Ba^{++} = BaCO_3(s) + 2K^+ + 2H_2O(l)$ (996.5)

T	$m_{(K_2CO_3)}$	$m_{(K_2SO_4)}$
298.1	2.663	0.000918

$K_2C_2O_4.2H_2O(s) = K_2C_2O_4(s) + 2H_2O(g)$ (849); *cf.* (916)* (E)

T	P	T	P
323.1	0.026	353.1	0.091
333.1	0.030	363.1	0.174
343.1	0.054	373.1	0.283

* According to Lowenstein (916), the decomposition results in the monohydrate as an intermediate product. At 298.1°K, for the compound $K_2C_2O_4.2H_2O$, $P = 0.0024$ to 0.0058; for the compound $K_2C_2O_4.H_2O$, $P = 0.0008$ to 0.0024.

$K_2C_4H_4O_6.\frac{1}{2}H_2O(s) = K_2C_4H_4O_6(s) + \frac{1}{2}H_2O(g)$ (918) (E)

T	P	T	P
287.3	0.0132	298.1	0.0241*
288.1	0.0138*	300.4	0.0267
291.6	0.0171	303.1	0.0313
293.1	0.0183*	305.1	0.0337
293.2	0.0184	308.1	0.0404*
294.8	0.0195	308.5	0.0403
297.0	0.0216	313.1	0.0525

*Interpolations from $t = 1.15t_w + 1.2$.

$K_2SiF_6(s) = (?) + SiF_4(g)$ (1398) (E)

T	P	T	P
1 248.1	0.0308	1 398.1	0.2423
1 299.1	0.0439	1 420.1	0.5293
1 349.1	0.0968	1 453.1	1.512
1 383.1	0.1780		

$K_2Zn(SO_4)_2.6H_2O(s) = K_2Zn(SO_4)_2.2H_2O(s) + 4H_2O(g)$ (264) (E)

$\log P = 7.953 - 2\,992/T$

T	P	T	P
289.3	0.0047*	322.3	0.0450
309.0	0.0186	325.4	0.0584*
311.2	0.0213*	330.3	0.0784
311.8	0.0218	336.5	0.1146
318.5	0.0359*	$\Delta H = 55\,200$	

* Measured on cooling.

$K_2HgI_4.2NH_3(s) = (?)$ (1134) (E)

$K_2MnO_4(s) = K_2MnO_3(s) + \frac{1}{2}O_2(g)$ (27, 43); *cf.* (28, 1012)

T	P	T	P
683.1*	0.003	883.1	0.1822
727.1*	.007	887.1	.2030
776.1	.0084	889.1*	.310
780.1	.0145	891.1	.2224
786.1	.0174	902.1	.2908
789.1	.0199	904.1	.3079
816.1	.0359	906.1	.3201
821.1*	.053	915.1	.3868
834.1	.0538	925.1*	.747
845.1	.0692	926.1	.5020
850.1	.0789	934.1	.617
859.1*	.143	940.1	.700
873.1	.1444	941.1*	1.005
879.1	.1632		

* From (27); all other values from (43).

$K_2Mn(SO_4)_2.6H_2O(s) = K_2Mn(SO_4)_2.2H_2O(s) + 4H_2O(g)$ (399) (E)

T	P	T	P
328.1	0.133	353.1	0.430
335.1	0.195	358.6	0.549
340.6	0.245	364.1	0.670
345.1	0.303	368.1	0.780
350.1	0.388	372.1	0.896

$FeCl_3.2KCl.6NH_3(s) = (?)$ (395) (E)

T	P	T	P
273.1	0.171	299.6	0.592
287.1	0.362	305.1	0.737
293.6	0.480	313.6	0.947

$K_2Fe(SO_4)_2.6H_2O(s) = K_2Fe(SO_4)_2.4H_2O(s) + 2H_2O(g)$ (265) (E)

$\log P = 3.887 - 866.5/T - 244\,400/T^2$

T	P	T	P
298.2	0.0276	324.3	0.1203
299.7	0.0311	328.8	0.1490
305.6	0.0433	334.8	0.1955
312.1	0.0636*	339.7	0.2458
318.1	0.0880	344.6	0.3012
323.8	0.1291	$\Delta H = 20\,800$	

* Measured on cooling.

$K_2Co(SO_4)_2.6H_2O(s) = K_2Co(SO_4)_2.2H_2O(s) + 4H_2O(g)$ (265) (E)

$\log P = 3.853 - 265.7/T - 451\,350/T^2$

T	P	T	P
299.6	0.0095	327.1	0.0704*
300.7	0.0109*	330.1	0.0845
305.9	0.0153	333.7	0.1074
312.7	0.0253	339.3	0.1491*
318.8	0.0403	339.4	0.1505
324.2	0.0582	349.4	0.2649
	$\Delta H = 56\,000$		

* Measured on cooling.

$K_2Ni(SO_4)_2.6H_2O(s) = K_2Ni(SO_4)_2.2H_2O(s) + 4H_2O(g)$ (265, 399) (E)

$\log P = -1.900 + 3\,329/T - 1\,039\,000/T^2$

T	P	T	P
306.9	0.0082	333.9	0.0563*
318.2	0.0192	339.6	0.0784*
321.7	0.0255*	349.3	0.1291
328.9	0.0411	370.1†	0.151
	$\Delta H = 56\,400$		

* Measured on cooling. † From (399); all other values from (265).

$K_2Mg(SO_4)_2.6H_2O(s) = K_2Mg(SO_4)_2.4H_2O(s) + 2H_2O(g)$ (265); cf. (399) (E)

$\log P = 3.982 - 908.3/T - 221\,950/T^2$

T	P	T	P
323.9	0.1153	330.4	0.1583*
327.4	0.1367	318.0	0.0846*
333.4	0.1822	309.3	0.0529*
338.0	0.2253	300.3	0.0322*
343.5	0.2856	$\Delta H = 20\,800$	

* Measured on cooling.

$K_3[Fe(C_2O_4)_3].2H_2O(s) = K_3[Fe(C_2O_4)_3](s) + 2H_2O(g)$ (E)

$P_{298.1} = 0\text{–}0.0007$ (916)

$K_3[Fe(C_2O_4)_3].6H_2O(s) = K_3[Fe(C_2O_4)_3].2H_2O(s) + 4H_2O(g)$ (E)

$P_{298.1} = 0.0008 - 0.0024$ (916)

$K_4[Fe(CN)_6].3H_2O(s) = K_4[Fe(CN)_6](s) + 3H_2O(g)$ (849, 1325) (E)

T	P	T	P
288.1*	0.0070	303.1*	0.0193
293.1	0.0094	333.1	0.145
293.1*	0.0096	343.1	0.224
298.1*	0.0134	353.1	0.368

* From (1325); all other values from (849).

$Hg(l) + Cl^- + K_3[Fe(CN)_6](aq) + K^+ = K_4[Fe(CN)_6](aq) + HgCl(s)$ (889, 898, 1332)

$m_{(KCl)}$ (898)	$E^0_{298.1}$	$m_{(KCl)}$ (898)	$E^0_{298.1}$
0.050	0.2269	1.572	0.2187
.100	.2209	2.007	.2192
.500	.2187	3.320	.2190
1.031	.2184	4.284	.2188

$m_{(KCl)}$ (889)	$E^0_{298.1}$	$m_{(KCl)}$ (889)	$E^0_{298.1}$
0.05	0.2264	0.4	0.2190
.1	.2217	.8	.2184
.2	.2190		

$m_{(KCl)}$ (1322)	$E^0_{298.1}$	$m_{(KCl)}$ (1322)	$E^0_{298.1}$
0.005	0.2776	0.200	0.2310
.010	.2693	.250	.2279
.025	.2507	.300	.2234
.050	.2401	.400	.2260
.100	.2322		

Rb, Rubidium

$Rb(s)$; ΔH, $\Delta F^0 = 0$

$Rb(s) = Rb^+ + E^-$

$E^0_{298.1} = 2.9242$; $\Delta F^0_{298.1} = -67\,473$ (885) *from* (861)

$RbBr.3NH_3(s) = RbBr(s) + 3NH_3(g)$ (100) (E)

T	P	T	P
194.6	0.0454	203.1	0.0809
	$\Delta H = 21\,300$		

$RbBrCl_2(s) = (?)$ (382) (E)

T	P	T	P
	First form		
290.1	0.026	356.6	0.599
330.1	0.099	364.6	0.920
345.6	0.309	366.1	1.000
	Second form		
334.3	0.204	365.1	0.895
355.1	0.487		

$RbBr_2Cl(s) = (?)$ (382) (E)

T	P	T	P
291.1	0.039	350.1	0.737
323.1	0.105	353.1	0.921
335.1	0.316	354.1	1.000
342.1	0.447		

$RbBr_3(s) = (?)$ (382) (E)

T	P	T	P
336.1	0.115	373.2	0.743
356.1	0.325	374.6	0.800
366.3	0.542	378.6	1.000

$RbI.4SO_2(s) = (?) + xSO_2(g)$ (392) (E)

T	P	T	P
273.1	0.380	285.6	0.829
278.1	0.530	286.6	0.882
282.1	0.684	288.6	1.000 (extrap.)
283.9	0.759	$\Delta H = 10\,030x$	

$RbI.6NH_3(s) = RbI(s) + 6NH_3(g)$ (100) (E)

T	P	T	P
194.6	0.017	203.1	0.041
	$\Delta H = 45\,000$		

$RbICl_2(s) = (?)$ (382) (E)

T	P	T	P
	First form		
370.1	0.105	407.1	0.530
382.1	0.192	424.1	1.000 (extrap.)
393.1	0.309		
	Second form		
385.1	0.039	451.1	0.461
405.1	0.101	459.1	0.645
424.1	0.187	467.1	0.822
439.1	0.322		

$RbIBr_2(s) = (?)$ (382) (E)

T	P	T	P
379.1	0.059	438.1	0.507
398.6	0.146	447.6	0.664
410.1	0.213	453.1	0.789
420.1	0.303	459.6	1.000
429.1	0.395		

$RbI_3(s) = (?)$ (382) (E)

T	P	T	P
439.1	0.395	455.1	0.678
446.6	0.495	465.1	1.000 (extrap.)

$RbCNS.1\tfrac{1}{2}SO_2(s) = (?) + xSO_2(g)$ (392) (E)

T	P	T	P
273.1	0.097	292.1	0.382
284.6	0.216	304.6	1.000 (extrap.)
	$\Delta H = 10\,640x$		

$RbTi(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (399) (E)

T	P	T	P
313.1	0.009	353.1	0.201
323.1	0.024	363.1	0.353
333.1	0.057	373.1	0.691
344.1	0.117	378.1	0.921

$RbFe(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (399) (E)

T	P	T	P
298.1	0.005	321.1	0.079
306.1	0.020	329.1	0.150
314.1	0.043		

$RbCr(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (399) (E)

T	P	T	P
313.1	0.033	344.1	0.218
324.1	0.055	357.1	0.467
334.6	0.113	363.1	0.545

$RbV(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (399) (E)

T	P	T	P
326.1	0.070	354.1	0.399
334.6	0.121	363.6	0.588
345.6	0.264		

$RbAl(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (399) (E)

T	P	T	P
323.1	0.038	363.1	0.354
333.1	0.059	368.1	0.476
343.1	0.109	370.1	0.517
353.1	0.196		

$Rb_2CO_3(s) = Rb_2O(s) + CO_2(g)$ (836, 837) (E)

T	P	T	P
936.1	0.000	1 173.1	0.013
1 013.1	0.003	1 263.1	0.024
1 103.1	0.008	1 293.1	0.026
1 143.1	0.011	1 353.1	0.043

$2RbHCO_3(s) = Rb_2CO_3(s) + H_2O(g) + CO_2(g)$ (267) (E)
$\Delta H = 19\ 780$; $\log P = 9.831 - 4\ 300/T$

T	P	T	P
379.6	0.0678	425.0	0.5341
384.5	0.100	426.6	0.5872
393.2	0.128	431.7	0.7400
409.6	0.2857	434.1	0.8207
419.9	0.4251	437.1	0.9868
420.2	0.4514	443.7	1.3663

$Rb_2Zn(SO_4)_2.6H_2O(s) = Rb_2Zn(SO_4)_2.2H_2O(s) + 4H_2O(g)$
$\log P = 0.858 + 1\ 804/T - 845\ 640/T^2$ (264) (E)

T	P	T	P
306.4	0.0047	337.8	0.0605
314.3	0.0104	339.3	0.0680*
319.9	0.0175*	343.3	0.0855*
320.7	0.0179	350.6	0.1318
328.4	0.0329*	354.6	0.1646
328.7	0.0332	$\Delta H = 62\ 000$	

* Measured on cooling.

$Rb_2Cd(SO_4)_2.6H_2O(s) = Rb_2Cd(SO_4)_2.2H_2O(s) + 4H_2O(g)$
$\log P = -1.636 + 2\ 735/T - 816\ 170/T^2$ (265) (E)

T	P	T	P
301.1	0.0304	334.8	0.1875
307.7	0.0461	340.6	0.2427
313.2	0.0629	320.3	0.0916*
318.6	0.0841	311.0	0.0561*
324.0	0.1120	305.7	0.0411*
329.5	0.1469	$\Delta H = 42\ 000$	

* Measured on cooling.

$Rb_2Mn(SO_4)_2.6H_2O(s) = Rb_2Mn(SO_4)_2.2H_2O(s) + 4H_2O(g)$ (265, 399) (E)
$\Delta H = 52\ 000$; $\log P = -10.965 + 8\ 419/T - 1\ 781\ 000/T^2$ (265)

T	P	T	P
300.6*	0.0220	339.1	0.239
307.5*	0.0378	343.8*	0.2850
314.1*	0.0603	348.1	0.355
319.8*	0.0887	357.1	0.493
326.5*	0.1296	363.1	0.629
328.1	0.136	368.1	0.757

* From (265); all other values from (399).

$Rb_2Co(SO_4)_2.6H_2O(s) = Rb_2Co(SO_4)_2.2H_2O(s) + 4H_2O(g)$
$\log P = 0.859 + 1\ 594/T - 762\ 740/T^2$ (265) (E)

T	P	T	P
300.5	0.0054*	325.7	0.0354
301.3	0.0057	326.4	0.0379*
306.4	0.0089	332.0	0.0549
308.9	0.0105*	338.2	0.0788
311.5	0.0118	349.2	0.1476
318.4	0.0214	$\Delta H = 57\ 600$	

* Measured on cooling.

$Rb_2Ni(SO_4)_2.6H_2O(s) = Rb_2Ni(SO_4)_2.2H_2O(s) + 4H_2O(g)$
$\log P = 7.682 - 2\ 937/T - 44\ 740/T^2$ (265, 399) (E)

T	P	T	P
305.6	0.0039	347.9	0.0733
307.5	0.0046*	348.1†	0.0711
313.2	0.0072	363.1†	0.103
322.7	0.0138	378.1†	0.168
325.0	0.0170*	383.1†	0.207
331.4	0.0262	388.1†	0.251
340.2	0.0463*	$\Delta H = 57\ 600$	

* Measured on cooling. † From (399); all other values from (265).

$Rb_2Mg(SO_4)_2.6H_2O(s) = Rb_2Mg(SO_4)_2.4H_2O(s) + 2H_2O(g)$ (265); *cf.* (399) (E)
$\Delta H = 20\ 800$; $\log P = 4.871 - 1\ 148/T - 264\ 030/T^2$

T	P	T	P
304.5	0.0178	330.5	0.0928*
317.0	0.0416	319.4	0.0470*
340.0	0.1617	301.9	0.0151*

* Measured on cooling.

Cs, Cesium

$CsBrCl_2(s) = (?)$ (382) (E)

T	P	T	P
352.1	0.059	405.6	0.805
372.1	0.164	408.4	0.895
385.1	0.300	411.1	1.000
397.6	0.553		

$CsBr_2Cl(s) = (?)$ (382) (E)

T	P	T	P
327.1	0.020	387.1	0.634
350.1	0.118	393.1	0.821
364.1	0.224	395.6	0.901
377.1	0.417	397.1	1.000

$CsBr_3(s) = CsBr(s) + Br_2(g)$ (382) (E)

T	P	T	P
364.9	0.087	411.6	0.717
382.6	0.204	416.6	0.862
404.1	0.509	420.6	1.000

$CsICl_2(s) = (?)$ (382) (E)

T	P	T	P
385.1	0.032	466.1	0.599
407.1	0.092	472.6	0.730
420.1	0.136	477.6	0.842
430.1	0.184	479.1	0.895
439.1	0.243	480.1	0.928
442.1	0.267	482.1	1.000
451.6	0.359		

$CsI.4SO_2(s) = (?) + xSO_2(g)$ (392) (E)

T	P	T	P
252.6	0.092	285.6	0.776
261.6	0.171	289.1	0.934
272.6	0.329	290.1	1.000 (extrap.)
279.1	0.513	$\Delta H = 10\ 890x$	

$CsIBr_2(s) = (?)$ (382) (E)

T	P	T	P
430.1	0.059	492.1	0.450
443.1	0.112	504.1	0.666
462.6	0.211	508.1	0.789
479.1	0.316	515.6	1.000

$CsI_2Br(s) = (?)$ (382) (E)

T	P	T	P
445.1	0.382	468.6 M. P.	0.816
455.6	0.520	473.1	0.862
464.1	0.672	474.6	1.000 (extrap.)

$CsI_3(s) = CsI(s) + I_2(g)$ (382) (E)

T	P	T	P
333.2*	0.0000395	470.1	0.147
353.1*	0.000256	479.1†	0.211
432.1	0.026	488.1	0.254
444.1	0.051	499.1	0.322
458.1	0.091	510.1	0.454
463.1	0.113	(523.1)	(1.0)‡

* From (1045). † The compound melts at $T = 480.6$. ‡ Extrapolation of the curve of the solid substance.

$CsCNS.\frac{1}{2}SO_2(s) = (?) + xSO_2(g)$ (392) (E)

T	P	T	P
257.6	0.164	284.6	0.678
273.1	0.408	292.1	0.967
282.6	0.618	$\Delta H = 10\ 140x$	

$CsTi(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (399) (E)

T	P	T	P
298.1	0.009	334.1	0.192
303.1	0.018	345.1	0.321
311.1	0.041	353.1	0.455
318.1	0.072	363.1	0.679
325.1	0.109	368.1	0.807

$CsMn(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (E)

$P_{302.1} = 0.018$ (399)

$CsFe(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (399) (E)

T	P	T	P
313.1	0.024	353.1	0.487
325.1	0.074	363.1	0.704
335.1	0.184		

$CsCo(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (399) (E)

T	P	T	P
300.1	0.005	312.1*	0.033

* Above 313.1 decomposition sets in.

$CsCr(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (399) (E)

T	P	T	P
287.1	0.018	368.1	0.674
344.9	0.157	370.1	0.721
353.1	0.295	376.1	0.934
363.1	0.541		

$CsCr(SeO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (399) (E)

T	P	T	P
323.1	0.020	353.1	0.272
334.1	0.074	363.1	0.487
345.1	0.157	368.1	0.607

$CsV(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (399) (E)

T	P	T	P
323.1	0.033	352.1	0.287
333.1	0.088	359.1*	0.428
344.1	0.183	363.1	0.543

* Decomposition begins.

$CsAl(SO_4)_2.12H_2O(s) = (?) + xH_2O(g)$ (399) (E)

T	P	T	P
323.1	0.017	368.1	0.362
334.1	0.043	373.1	0.488
348.1	0.124	378.1	0.624
358.1	0.209		

$2CsHCO_3(s) = Cs_2CO_3(s) + CO_2(g) + H_2O(g)$ (266) (E)

$\log P = 14.049 - 6\ 300/T$

T	P	T	P
376.1	0.0379	439.1	0.5260
391.0	0.0625	443.0	0.6607
406.2	0.1041	445.3	0.7891
413.1	0.1325	450.1	1.1146
424.7	0.2222	451.2	1.2041
431.2	0.3089	452.9	1.3678
436.1	0.4248	$\Delta H = 28\ 980$	

$Cs_2CO_3(s) = Cs_2O(s) + CO_2(g)$ (837) (E)

T	P	T	P
883.1	0.003	1 273.1	0.058
953.1	0.005	1 323.1	0.083
1 078.1	0.008	1 366.1	0.118
1 133.1	0.011	1 403.1	0.159
1 163.1	0.016	1 423.1	0.181
1 253.1	0.042	1 453.1	0.207

$Cs_2Zn(SO_4)_2.6H_2O(s) = Cs_2Zn(SO_4)_2.2H_2O(s) + 4H_2O(g)$

$\log P = -1.148 + 3\ 135/T - 1\ 059\ 800/T^2$ (264) (E)

T	P	T	P
307.5	0.0071*	326.5	0.0332
307.5	0.0078	332.9	0.0505
314.1	0.0122	333.9	0.0541*
317.4	0.0167*	343.8	0.1005
319.8	0.0197	$\Delta H = 62\ 400$	

* Measured on cooling.

$Cs_2Cd(SO_4)_2.6H_2O(s) = Cs_2Cd(SO_4)_2.2H_2O(s) + 4H_2O(g)$

$\Delta H = 42\ 400$; $\log P = 1.878 + 471.2/T - 449\ 370/T^2$ (265) (E)

T	P	T	P
298.8	0.0226	324.9	0.111
305.1	0.0371	334.1	0.1712
307.6	0.0416	337.5	0.1989
313.3	0.0607	321.5	0.0950*
319.2	0.0826	306.7	0.0397*

* Measured on cooling.

$Cs_2Mn(SO_4)_2.6H_2O(s) = Cs_2Mn(SO_4)_2.2H_2O(s) + 4H_2O(g)$ (265, 399) (E)

$\log P = -0.051 + 2\ 263/T - 830\ 860/T^2$ (265)

T	P	T	P
301.6*	0.0183	340.1	0.225
309.5*	0.0314	350.1	0.347
316.9*	0.0522	358.1	0.476
324.8*	0.0918	363.1	0.589
328.9*	0.1162	369.1	0.741
329.1	0.118	374.1	0.889
338.5*	0.2004	$\Delta H = 53\ 200$*	

* From (265); all other values from (399).

$Cs_2Co(SO_4)_2.6H_2O(s) = Cs_2Co(SO_4)_2.2H_2O(s) + 4H_2O(g)$

$\Delta H = 57\ 200$; $\log P = 5.283 - 1\ 221/T - 313\ 270/T^2$ (265) (E)

T	P	T	P
302.3	0.0067	326.9	0.0412
314.1	0.0160	331.9	0.0579*
316.2	0.0197*	333.3	0.0626
320.1	0.0258	339.3	0.0926
324.7	0.0349*	348.1	0.1559

* Measured on cooling.

$Cs_2Ni(SO_4)_2.6H_2O(s) = Cs_2Ni(SO_4)_2.2H_2O(s) + 4H_2O(g)$ (265); *cf.* (399) (E)

$\Delta H = 53\ 600$; $\log P = -4.611 + 4\ 798/T - 1\ 249\ 600/T^2$

T	P	T	P
308.1	0.0063	329.0	0.0249
317.3	0.0118	338.8	0.0466
321.8	0.0166	355.1	0.0989

$Cs_2Mg(SO_4)_2.6H_2O(s) = Cs_2Mg(SO_4)_2.4H_2O(s) + 2H_2O(g)$ (265); *cf.* (399) (E)

$\Delta H = 50\ 800$; $\log P = 3.716 - 751.8/T - 260\ 600/T^2$

T	P	T	P
303.1	0.0249	330.1	0.1116
309.7	0.0370	340.8	0.1833
321.8	0.0725	326.3	0.0908*

* Measured on cooling.

DEHYDRATION BEHAVIOR OF MINERALS (E)

$K_aSi_bO_c.xH_2O = (?) + yH_2O$

Potassium Silicate Hydrate

The results of the detailed work of Morey (1016) cannot be interpreted in a short abstract.

Kaolin

The results of Tammann and Pape (1424) cannot be interpreted in a short abstract.

Zeolite (916)

Maximum loss in weight over H_2SO_4 of various concentrations at 298.1°K. The pressure of this hydrate changes continuously with the temperature, the residue remaining clear. The pressure is equal to that of a sulfuric acid solution, for which the compound does not change in weight.

Chabasite (916)

% H_2SO_4	$p_{H_2SO_4}$	H_2O, Mole loss	% H_2SO_4	$p_{H_2SO_4}$	H_2O, Mole loss
10	0.02839	0.06	60	0.00580	0.53
20	0.02579	0.12	70	0.00230	0.90
30	0.02320	0.20	80	0.00074	1.46
40	0.01769	0.26	90	0.0003	2.12
50	0.01161	0.30	97	0.00	2.22

Desmine (916)

% H_2SO_4	$p_{H_2SO_4}$	H_2O, Mole loss	% H_2SO_4	$p_{H_2SO_4}$	H_2O, Mole loss
10	0.02839	0.04	60	0.00580	0.32
20	0.02579	0.07	70	0.00230	0.46
30	0.02320	0.11	80	0.00074	0.69
40	0.01769	0.15	90	0.0003	1.47
50	0.01161	0.22	97	0.00	1.80

Heulandite (916)

% H_2SO_4	$p_{H_2SO_4}$	H_2O, Mole loss	% H_2SO_4	$p_{H_2SO_4}$	H_2O, Mole loss
10	0.02839	0.02	60	0.00580	0.27
20	0.02579	0.04	70	0.00230	0.39
30	0.02320	0.08	80	0.00074	0.53
40	0.01769	0.12	90	0.0003	1.26
50	0.01161	0.17	97	0.00	1.53

Potassium Chabasite (916)

% H_2SO_4	$p_{H_2SO_4}$	H_2O, Mole loss	% H_2SO_4	$p_{H_2SO_4}$	H_2O, Mole loss
10	0.02839	0.08	60	0.00580	1.16
20	0.02579	0.14	70	0.00230	1.56
30	0.02320	0.27	80	0.00074	2.23
40	0.01769	0.38	90	0.0003	3.07
50	0.01161	0.72	97	0.00	3.14

Potassium Desmine (916)

% H_2SO_4	$p_{H_2SO_4}$	H_2O, Mole loss	% H_2SO_4	$p_{H_2SO_4}$	H_2O, Mole loss
10	0.02839	0.04	60	0.00580	0.66
20	0.02579	0.11	70	0.00230	0.89
30	0.02320	0.18	80	0.00074	1.16
40	0.01769	0.26	90	0.0003	2.14
50	0.01161	0.44	97	0.00	2.24

Potassium Heulandite (916)

% H_2SO_4	$p_{H_2SO_4}$	H_2O, Mole loss	% H_2SO_4	$p_{H_2SO_4}$	H_2O, Mole loss
10	0.02839	0.00	60	0.00580	0.51
20	0.02579	0.07	70	0.00230	0.72
30	0.02320	0.14	80	0.00074	1.13
40	0.01769	0.20	90	0.0003	2.08
50	0.01161	0.36	97	0.00	2.18

Ammonium Desmine (916)

% H_2SO_4	$p_{H_2SO_4}$	H_2O, Mole loss	% H_2SO_4	$p_{H_2SO_4}$	H_2O, Mole loss
10	0.02839	0.04	60	0.00580	0.81
20	0.02579	0.14	70	0.00230	1.26
30	0.02320	0.21	80	0.00074	1.88
40	0.01769	0.34	90	0.0003	2.34
50	0.01161	0.52	97	0.000	2.46

Calcium Chabasite (916)

% H_2SO_4	$p_{H_2SO_4}$	H_2O, Mole loss	% H_2SO_4	$p_{H_2SO_4}$	H_2O, Mole loss
10	0.02839	0.07	60	0.00580	0.54
20	0.02579	0.13	70	0.00230	0.93
30	0.02320	0.22	80	0.00074	1.49
40	0.01769	0.26	90	0.0003	2.15
50	0.01161	0.31	97	0.00	2.26

Calcium Heulandite (916)

% H_2SO_4	$p_{H_2SO_4}$	H_2O, Mole loss	% H_2SO_4	$p_{H_2SO_4}$	H_2O, Mole loss
10	0.02839	0.02	60	0.00580	0.28
20	0.02579	0.04	70	0.00230	0.41
30	0.02320	0.09	80	0.00074	0.56
40	0.01769	0.13	90	0.0003	1.29
50	0.01161	0.18	97	0.00	1.57

Calcium Desmine (916)

% H_2SO_4	$p_{H_2SO_4}$	H_2O, Mole loss	% H_2SO_4	$p_{H_2SO_4}$	H_2O, Mole loss
10	0.02839	0.04	60	0.00580	0.34
20	0.02579	0.07	70	0.00230	0.49
30	0.02320	0.11	80	0.00074	0.73
40	0.01769	0.16	90	0.0003	1.50
50	0.01161	0.24	97	0.00	1.73

For the following zeolites studied by Tammann (1422), the first column (1) gives the pressure of the H_2SO_4 solution, over which the mineral was kept; the second column (2) gives the maximum loss of water in wt. %; the third column (3) gives how much wt. % of water would not be absorbed again for the rehydration of the dehydrated mineral on standing over the said sulfuric acid solution.

(1)	(2)	(3)	(1)	(2)	(3)
Gmelinite, $CaNa_2Al_2Si_4O_{12}.6H_2O$ (1422)					
0.02068	0.05	0.05	0.00386	1.40	1.41
0.01914	0.08		0.00162	2.48	3.11
0.01642	0.18		0.00051	4.19	4.58
0.01199	0.42		0.00014	4.58	
0.00796	0.75				

DEHYDRATION OF MINERALS.—*(Continued)*

(1)	(2)	(3)	(1)	(2)	(3)
Phacolite, $CaNa_2Al_2Si_4O_{12}.6H_2O$ (1422)					
0.02068	0.05	0.05	0.00386	1.81	1.76
0.01914	0.16		0.00162	2.90	
0.01642	0.31		0.00051	3.82	4.56
0.01199	0.60		0.00014	4.47	
0.00796	1.06				
Chabasite, $CaNa_2Al_2Si_4O_{12}.6H_2O$ (1422)					
0.01914	0.11		0.00162	1.69	
0.01642	0.14		0.00014	3.14	
0.01199	0.37				
Leonhardite, $CaAl_2Si_4O_{12}.4H_2O$ (1422)					
0.01914	0.06		0.00051	3.40	
0.01199	0.70				
Laumontite, $CaAl_2Si_4O_{12}.4H_2O$ (1422)					
0.01914	0.05		0.00051	0.58	
Phillipsite, $(CaK_2)Al_2Si_5O_{14}.5H_2O$ (1422)					
0.01914	0.18		0.00386	0.40	
0.01642	0.22		0.00051	1.41	
0.01199	0.24				
Gismondite (1422)					
0.01914	0.02	0.16	0.00386	1.48	
0.01642	0.19		0.00162	2.51	
0.01199	0.25	0.29	0.00051	3.42	
0.00796	0.94		0.00014	3.73	
Okenite, $CaO.2SiO_2.2H_2O$ (1422)					
0.02068	0.06	0.27	0.00386	2.10	
0.01914	0.84		0.00162	2.66	
0.01642	1.02	1.25	0.00051	3.21	
0.01199	1.29	1.49	0.00014	3.56	
0.00796	1.67				
Natrolite, $Na_2Al_2Si_3O_{10}.2H_2O$ (1422)					
0.01914	0.21		0.01199	0.39	
0.01642	0.25		0.00051	0.79	
Scolecite, $CaAl_2Si_3O_{12}.3H_2O$ (1422)					
0.02068	0.000	0.000	0.00796	0.029	0.029
0.01914	0.004		0.00386	0.042	
0.01642	0.013		0.00162	0.079	
0.01199	0.017		0.00014	0.105	
Pyrophyllite, $Al_2Si_4O_{11}.H_2O$ (1422)					
0.02068		0.000	0.00796	0.050	
0.01914	0.004		0.00386	0.059	
0.01642	0.013		0.00014	0.060	
0.01199	0.017				
Pitchstone (1422)					
Brown form					
0.02068	0.005		0.00386	0.42	
0.01914	0.005		0.00162	0.60	
0.01642	0.04		0.00051	0.84	
0.01199	0.08		0.00014	0.92	
0.00796	0.17				
Green form					
0.01642	0.04		0.00162	0.75	
0.01199	0.08		0.00051	0.95	
0.00796	0.31		0.00014	1.06	
0.00386	0.57				
Black form					
0.01914	0.01		0.00386	0.04	
0.01642	0.02		0.00162	0.05	
0.01199	0.02		0.00051	0.06	
0.00796	0.04				
Semiopal (1422)					
0.01914	2.96	8.28	0.00386	11.60	
0.01642	3.90	10.80	0.00162	12.09	
0.01199	9.95		0.00014	13.30	
0.00796	10.75	12.18			
Hyalite (1422)					
0.01914		0.00	0.00386	0.05	
0.01642	0.01		0.00162	0.09	
0.01199	0.02		0.00051	0.10	
0.00796	0.03		0.00014	0.12	

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SOLUBILITY OF SLIGHTLY SOLUBLE SALTS IN AQUEOUS SOLUTIONS OF ELECTROLYTES

MERLE RANDALL AND WILLIAM V. VIETTI

The Standard arrangement (Vol. III, p. viii) is used throughout this section. Under each A-component, printed in large type, are listed the B-components in the standard order. The A-component is the slightly soluble salt; the B-component is a solute in the aqueous solution.

L'arrangement type (Vol. III, p. viii) est utilisé dans toute cette section. Sous chaque constituant A, imprimé en grands caractères, se trouvent les constituants B disposés en liste suivant l'ordre type. Le constituant A est le sel peu soluble; le constituant B est un corps dissous dans la solution aqueuse.

In diesem Abschnitt ist die Standardanordnung (Bd. III, S. viii) durchweg verwendet. Unter jeder A-Komponente, die in grossen Buchstaben gedruckt ist, folgen die B-Komponenten in Standardanordnung. Die A-Komponente ist der wenig lösliche Salz; die B-Komponente ist ein Körper in der wässrige Lösung.

In tutto questo capitolo si fa uso dell'ordinamento standard (Vol. III, p. viii). Sotto ogni componente A stampato in lettere grosse, sono elencati i componenti B con l'ordinamento standard. Il componente A è il sale poco solubile; il componente B è un soluto nella soluzione acquosa.

SYMBOLS AND ABBREVIATIONS

c_B Concentration of B-component in moles/liter.

$c_\pm$ Geometric mean of concentration of ions.

SYMBOLES ET ABRÉVIATIONS

c_B Concentration du constituant B en mol. gr./litre.

$c_\pm$ Moyenne géométrique de la concentration des ions.

SYMBOLE UND ABKÜRZUNGEN

c_B Konzentration der B-Komponente in Mol/Liter.

$c_\pm$ Geometrisches Mittel der Ionenkonzentrationen.

ABBREVIAZIONI E SIMBOLI

c_B Concentrazione del componente B in moli/litro.

$c_\pm$ Media geometrica della concentrazione degli ioni.

M Molal.
m_B Moles of B-component/1000 g H_2O *in vacuo.*
$\left.\begin{matrix} m_\pm \\ \overset{\circ}{m}_\pm \end{matrix}\right\}$ *See* p. 227.
N Normal
s_A Solubility of A-component in moles/liter.
S_A Solubility of A-component in moles/1000 g H_2O *in vacuo.*
γ Activity coefficient (*see* p. 227).
μ Ionic strength.
μ_c Ionic strength (for concentrations).
For other abbreviations, *see* p. 225.

M Moléculaire.
m_B Mol. gr. du constituant B/1000 g H_2O dans le vide.
$\left.\begin{matrix} m_\pm \\ \overset{\circ}{m}_\pm \end{matrix}\right\}$ *Voir* p. 227.
N Normal.
s_A Solubilité du constituant A en mol. gr./litre.
S_A Solubilité du constituant A en mol. gr./1000 g H_2O dans le vide.
γ Coefficient d'activité (*voir* p. 227).
μ Force ionique.
μ_c Force ionique (pour concentrations).
Pour d'autres abréviations, *voir* p. 225.

M Molar.
m_B Gramm Mol der B-Komponente/1000 g H_2O *in vacuo.*
$\left.\begin{matrix} m_\pm \\ \overset{\circ}{m}_\pm \end{matrix}\right\}$ *Siehe* S. 230.
N Normal.
s_A Löslichkeit der A-Komponente in Gramm Mol/Liter.
S_A Löslichkeit der A-Komponente in Gramm Mol/1000 g H_2O *in vacuo.*
γ Aktivitätskoeffiziente (*siehe* S. 230).
μ Ionenstärke.
μ_c Ionenstärke (für Konzentrationen).
Für andere Abkürzungen, *siehe* S. 228.

M Molare.
m_B Moli del componente B/1000 g di H_2O nel vuoto.
$\left.\begin{matrix} m_\pm \\ \overset{\circ}{m}_\pm \end{matrix}\right\}$ *Vedi* p. 230.
N Normale.
s_A Solubilità del componente A in moli/litro.
S_A Solubilità del componente A in moli/1000 g di H_2O nel vuoto.
γ Coefficiente di attività (*vedi* p. 230).
μ Forza ionica.
μ_c Forza ionica (per concentrazioni).
Per altre abbreviazioni, *vedi* p. 228.

$(CH_3)_4NI(s) = (CH_3)_4N^+ + I^-$

B = NH_4OH; T = 298.1°K (626)

c_B	s_A	c_B	s_A
0.000	0.26248	0.5224	0.26158
.0494	.26223	1.0149	.26062
.1001	.26200	2.1099	.25877
.2102	.26180		

B = KOH; T = 298.1°K (625,* 626)

c_B	s_A	c_B	s_A
0.000	0.26228	0.112	0.25810
.057	.25999	.251	.25073

* For c_B = 0.000 to 8.2962, *v.* (625).

$PbCl_2(s) = Pb^{++} + 2Cl^-$

B = HCl*

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
T = 273.1°K (375)			
0.0	0.02104	1.4766	0.252
.01371	.01624	1.4868	.250
.02743	.01299	1.4771	.2572
.05485	.00794	1.4670	.293
.08228	.00577	1.4314	.361
.1646	.00505	1.2707	.411
.2743	.00433	1.1534	.538
2.743	.00433	0.4947	1.657
5.485	.01877	0.0808	2.354
6.857	.0379	−0.0868	2.639
8.228	.06315	−0.2147	2.900
10.471	.1443	−0.4374	3.375
T = 291.1°K (1147)			
0.0	0.03358	1.2732	0.3170
.0001	.03346	1.2730	.318
.0002	.03344	1.2727	.318
.0005	.03326	1.2740	.317
.00102	.03310	1.2746	.317
.0102	.03019	1.2681	.320
T = 298.1°K (1076)			
0.0	0.03885	1.2093	0.341
.05	.02393	1.2133	.349
.10	.01621	1.1821	.385
.20	.00964	1.1113	.477
T = 298.3°K (373.5)			
0.0	0.0388	1.2105	0.341
.0009	.03866	1.2066	.342
.0022	.03820	1.2066	.342
.003	.03794	1.2080	.340
.0045	.03735	1.2078	.341
.0091	.03580	1.2108	.341
.0114	.03499	1.2117	.341
.0151	.03375	1.2126	.341
.0226	.03146	1.2127	.342
.0302	.02932	1.2126	.344
.0452	.02546	1.2124	.348
.0910	.01712	1.1900	.364
.1850	.01012	1.1234	.464
.3714	.00635	1.0095	.617
.5142	.00537	0.9433	.728
.7386	.00473	.8591	.868
1.026	.00441	.7753	1.020
1.538	.00461	.6524	1.245
2.051	.00518	.5525	1.437
2.564	.00625	.3991	1.607
3.085	.00778	.3754	1.763
3.718	.00816	.3146	1.934
5.00	.01938	.2871	2.249
7.50	.06586	.0943	2.774
10.0	.14135	−0.0582	3.229
12.05	.1643	−0.0989	3.541

* For values at 290.9°K, *v.* (73); at 273.1, 293.1, 313.1, 328.1, 359.1°K, *v.* (341).

B = HNO_3; T = 298.3°K (373.5)

0.001	0.03387	1.2097	0.343
.01	.03971	1.2004	.359
.051	.04291	.1666	.424
.01*	.04336	.1622	.424

* 0.01N HNO_3 + 0.04N KNO_3.

B = NH_4Cl

m_B	S_A	m_B	S_A
T = 290.1°K (326)			
0.0	0.323	0.8187	0.00263
.1817	.00762	.8432*	.00301
.4605	.00516		

* Complex in solid phase.

B = NH_4Cl.—(*Continued*)

m_B	S_A	$\log (1/m_\pm)$	$\mu^{\frac{1}{2}}$
T = 295.1°K (193)			
0.0	0.03745	1.2250	0.334
.1	.01625	1.1815	.385
.2	.0097	1.1102	.479
.3	.00765	1.0397	.569
.4	.0069	0.9758	.648
.5	.0065	.9222	.720
.52	.00635	.9148	.734

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
T = 298.3°K (373.5)			
0.0	0.03880	1.2105	0.341
.25	.00947	1.0548	.527
.50	.00711	0.9086	.722
1.00	.00435	.7630	1.005

m_B	S_A	$\log (1/m_\pm)$	$\mu^{\frac{1}{2}}$
T = 333.1°K (326)			
0.0	0.06404	0.9186	0.438
.09502	.03995	.9709	.463
.2886	.02472	.8497	.603
.4704	.02158	.7488	.732
.7529	.01887	.6428	.899
.8412	.02046	.5994	.950
.8763	.02204	.5763	.971
T = 373.1°K (326)			
0.0	0.11503	0.7386	0.587
.2535	.07440	.6390	.690
1.103	.06780	.3270	1.142
1.219	.06866	.2992	1.195
1.799	.07147	.1894	1.424

B = $C_2H_4O_2$, Acetic acid; T = 298.1°K (626)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.03877	1.2172	0.341
.050	.03891	1.2093	
.100	.03909	1.2073	
.150	.03880	1.2105	
.200	.03852	1.2136	
.465	.03696	1.2316	
.929	.03452	1.2612	
1.845	.02843	1.3455	
3.680	.01894	1.5218	

B = C_2H_6O, Ethyl alcohol; T = 298.1°K (758)

0.0	0.0388	1.2105	0.341
.0125	.0367	1.2347	
.025	.0338	1.2704	
.5	.0330	1.2989	
1.0	.0298	1.3251	
2.0	.0257	1.3893	
4.0	.0172	1.5638	

B = $C_6H_{14}O_6$, Mannitol; T = 298.1°K (758)

0.01563	0.0377	1.2230	
.03125	.0385	1.2138	
.0625	.0384	1.2497	
.125	.0394	1.2039	
.25	.0403	1.1939	
.5	.0408	1.1887	

B = $Pb(NO_3)_2$

m_B	S_A	$\log (1/m_\pm)$	$\mu^{\frac{1}{2}}$
T = 298.1°K (570)			
0.0	0.03903	1.2079	0.342
.01005	.03855	1.1798	.382
.02516	.03851	1.1410	.437
.0513	.03922	1.0847	.522
T = 298.1°K (24)			
0.1000	0.04204	0.9994	0.653
.250	.05127	.8331	.950

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
T = 298.1°K (570)			
0.0	0.03888	1.2099	0.341
.01001	.03838	1.1817	.381
.02503	.03832	1.1465	.436
.04983	.03899	1.0892	.517
.10*	.0416	1.0029	.652

* From (1076).

B = $ZnCl_2$; T = 298.1°K (1076)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.1	0.0110	1.0886	1.04

B = $CdCl_2$; T = 298.1°K (1076)

0.025	0.03005	1.1462	0.412
.05	.02405	1.0926	.472
.10	.01775	1.0023	.594

B = $HgCl_2$; T = 293.1°K (441)

c_B	s_A	c_B	s_A
0.0	0.03492	0.03683	.04413
.004604	.03569	.05*	.0496
.009208	.03665	.07367	.05348
.01842	.03886	.1474	.06822

* From (1076).

B = $MnCl_2$; T = 298.1°K (1076)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.025	0.02505	1.2001	0.387
.05	.01895	1.1478	.454
.10	.01085	1.0910	.577

B = $MgCl_2$; T = 298.1°K (1076)

0.025	0.02515	1.1990	0.730
.05	.0175	1.1621	.766

B = $CaCl_2$; T = 298.1°K (611)

0.0	0.03895	1.2088	0.342
.05*	.02515	1.1990	.388
.10*	.01775	1.1623	.450
.20	.01095	1.0894	.580
.26	.00696	0.9008	.894
.475	.00563	.7612	1.200
.955	.00771	.5114	1.699
1.515	.01268	.3089	2.140
2.06	.2057	.1495	2.499

* From (1076).

B = $CaBr_2$; T = 298.1°K

Solid phase contains $PbBr_2$(?) (611)

B = $SrCl_2$; T = 298.1°K (611)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.255	0.00678	0.9103	0.880
.51	.00640	.7219	1.245
.69	.00824	.6310	1.445
1.33	.01418	.3298	2.02
1.545	.01578	.2711	2.16
2.065	.02698	.1753	2.50

$PbCl_2$.—(*Continued*)

B = $\mathbf{SrBr_2}$; T = 298.1°K
Solid phase contains $PbBr_2$(?) (611)

B = $\mathbf{BaCl_2}$; T = 298.1°K (611)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.16	0.00699	1.0421	0.708
.32	.00553	0.8792	.988
.69	.01089	.5588	1.450
1.04	.02388	.3253	1.790

B = $\mathbf{BaBr_2}$; T = 298.1°K
Solid phase contains $PbBr_2$(?) (611)

B = **LiCl**; T = 323.1°K (326)

m_B	S_A	log $(1/m_\pm)$	$\mu^{1/2}$
0.4934	0.01649	0.7801	0.737
1.191	.01332	.5685	1.109
1.265	.01411	.5209	1.142
2.515	.01967	.2974	1.630
4.571	.03605	.0365	2.160
7.871	.1141	−0.2914	2.865
11.23	.2851	−0.5329	3.47
14.24	.4283	−0.6630	3.94
15.49	.4820	−0.7051	4.11
17.54	.5190	−0.7511	4.37
21.27	.5357	−0.7760	4.78
23.06	.4961	−0.8193	4.95

B = **NaCl**; T = 286.1°K (326)

m_B	S_A	m_B	S_A
0.0	0.02970	3.383	0.01337
.173	.00654	5.319	.05240
.903	.00344	6.221	.09396
2.65	.00794		

m_B	S_A	log $(1/m_\pm)$	$\mu^{1/2}$
T = 298.1°K (611)			
0.51	0.00648	0.9172	0.732
1.02	.00631	.7240	1.020
2.05	.00961	.4619	1.443
3.03	.01279	.3076	1.75
4.10	.04377	.0983	2.06
T = 323.1°K (326)			
0.2851	0.02111	0.8819	0.590
.7626	.01454	.6801	.898
1.428	.02328	.4359	1.220
2.83	.05309	.1132	1.725
3.463	.07005	.0138	1.915
4.121	.1165	−0.1134	2.115
4.856	.2069	−0.2531	2.34
5.173	.2599	−0.3085	2.44
T = 373.1°K (326)			
0.3565	0.06154	0.4823	0.736
.3638	.05974	.4843	.737
.7429	.05714	.4549	.956
.915	.05884	.3999	1.045
1.253	.06548	.3000	1.205
2.66	.1083	−0.0156	1.728
4.429	.2356	−0.2515	2.26
6.1307	.4830	−0.4293	2.75
6.346	.5223	−0.4858	2.81
6.704	.5855	−0.5207	2.91
7.181	.6900	−0.5685	3.04
7.27	.6928	−0.5725	3.06

B = **NaBr**; T = 298.1°K
Solid phase contains $PbBr_2$(?) (611)

B = **KCl**; T = 287.1°K (326)

m_B	S_A	m_B	S_A
0.0	0.03301	0.4769	0.00449
.1866	.0066	.5347*	.00567
.3358	.00517		

m_B	S_A	log $(1/m_\pm)$	$\mu^{1/2}$
T = 293.1°K (194)			
0.199	0.00967	1.1122	0.477
.306	.00744	1.0386	.573
.387	.00683	0.9873	.638
.475	.00648	.9373	.702
.497	.00652	.9235	.718
.502	.00643	.9228	.723
.523	.00644	.9110	.730
.545*	.00643	.8996	.750

* Solid phase contains $2PbCl_2.KCl$.

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
T = 298.1°K (1076)			
0.05	0.0241	1.2113	0.350
.10	.01705	1.1711	.389
.20	.1095	1.0894	.486
T = 298.3°K (373.5)			
0.0	0.0388	1.2105	0.341
.001	.03832	1.2128	.340
.0025	.03785	1.2151	.340
.0049	.03702	1.2123	.340
.0099	.03528	1.2138	.339
.02	.03216	1.2136	.341
.0599	.02262	1.2111	.357
.09991	.01690	1.1647	.387
.5006	.00740	0.9022	.610
.7018	.00738	.8088	.850
.9991	.00490	.7674	1.005
1.5018	.00483	.6524	1.23
2.0024	.00556	.5490	1.42
3.0036	.00974	.3502	1.74

m_B	S_A	log $(1/m_\pm)$	$\mu^{1/2}$
T = 298.1°K (326)			
0.1918	0.02840	0.9186	0.526
.3262	.02306	.8318	.628
.4860	.01880	.7626	.736
.6832	.02173	.6468	.865
.8476	.02237	.5831	.956
.8982	.02245	.5665	.982
.9213	.02248	.5593	.994
.9321	.02329	.5505	1.001
.9425	.02136	.5611	1.003
T = 373.1°K (326)			
0.1289	0.0838	0.7098	0.617
.143	.0844	.6942	.630
.431	.0656	.5600	.792
.5575	.06869	.4925	.874
.7234	.0667	.4395	.961
.8593	.0717	.3723	1.035
1.044	.0738	.3258	1.120
1.207	.0804	.2737	1.203
1.429	.08624	.2178	1.300
1.617	.1045	.1519	1.390
1.695	.10725	.1353	1.425

B = **KBr**; T = 298.1°K
Solid phase contains $PbBr_2$(?) (611)

B = $\mathbf{KNO_3}$; T = 298.3°K (373.5); *see* value in B = $\mathbf{HNO_3}$

$PbBr_2(s) = Pb^{++} + 2Br^-$

B = **HBr**; T = 283.1°K
Soln. contained $8.9m_B$ and $1.5S_A$ (341)

B = **HNO_3**; T = 298.1°K (373.5)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.00	0.02628	1.3797	0.281
.001	.02659	1.3746	.283
.01	.02735	1.3624	.304
.05*	.03025	1.3199	.375
.051	.03004	1.3216	.376

* 0.01N HNO_3 + 0.04N KNO_3.

B = **$Pb(NO_3)_2$**; T = 298.1°K (1192)

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.00	0.02680	1.3723	0.283
.0020	.02664	1.3634	.293
.0050	.02644	1.3520	.307
.0100	.02622	1.3340	.330
.0200	.02612	1.3001	.372
.0500	.02663	1.2202	.479
.1000	.02954	1.1169	.624
.1326	.03159	1.0612	.692
.2000	.03544	0.9757	.841
.3134	.04333	.8573	1.035
.5000	.05342	.7332	1.288
.703	.06522	.6279	1.519
.9521	.07754	.5354	1.737
1.6547	.1268	.3138	2.310
1.964*	.1346	−0.2727	2.510

* Solid phase, $PbBr_2$ and $Pb(NO_3)_2$.

B = **$CdBr_2$**; T = 298.1°K (1192)

0.0010	0.02637	1.3674	0.286
.0020	.02591	1.3643	.289
.0050	.02466	1.3539	.298
.0100	.02307	1.3321	.315
.0200	.01999	1.2977	.346
.0500	.01450	1.2059	.440
.1000	.01117	1.0860	.577
.1305	.01038	1.0281	.650
.2000	.00939	0.9280	.793
.3236	.00969	.7890	1.000
.5000	.01072	.6505	1.238
.5607	.01143	.6083	1.310
1.000	.01597	.3939	1.745
1.692	.02445	.1803	2.270
4.182*	.06508	.2170	3.570

* Solid phase, $PbBr_2$ and $CdBr_2.4H_2O$.

B = **$CaCl_2$**; T = 298.1°K
Solid phase probably contained $PbCl_2(s)$ (611)

B = **$CaBr_2$**; T = 298.1°K (611)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.00	0.02625	1.3803	0.281
.26	.00667	0.9073	.893
.52	.01205	.6217	1.255
1.04	.0438	.2289	1.803
1.565	.1175	−0.0411	2.246
2.085	.5187	−0.3827	2.795

B = **$SrCl_2$**; T = 298.1°K
Solid phase probably contained $PbCl_2(s)$ (611)

B = **$SrBr_2$**; T = 298.1°K (611)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.26	0.00673	0.9060	0.883
.52	.01273	.6134	1.264
1.04	.04367	.2294	1.798
1.56	.1559	−0.0880	2.269
2.08	.5687	−0.4010	2.819

B = **$BaCl_2$**; T = 298.1°K
Solid phase probably contained $PbCl_2(s)$ (611)

B = **$BaBr_2$**; T = 298.1°K (611)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.225	0.00607	0.9624	0.832
.455	.01091	.6745	1.182
.91	.04443	.2639	1.692
1.38	.1604	−0.0609	2.150
1.835	.4140	−0.3077	2.597

B = **$Ba(NO_3)_2$**; T = 298.1°K (1192)

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.002	0.02737	1.3664	0.297
.005	.02808	1.3509	.315
.01	.02883	1.3395	.341
.02	.03034	1.3173	.389
.05000	.03370	1.2717	.501
.09045	.03691	1.2322	.618
.1000	.03780	1.2219	.693
.2000	.04385	1.1574	.855
.2105	.04428	1.1532	.874
.3513	.05008	1.0997	1.097
.4116*	.05337	1.0720	1.222

* Solid phase, $PbBr_2(s)$ and $Ba(NO_3)_2(s)$.

B = **NaCl**, T = 298.1°K
Solid phase probably contained $PbCl_2(s)$ (611)

B = **NaBr**; T = 298.1°K (611)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.73	0.00860	0.7727	0.869
1.47	.02247	.4292	1.240
2.20	.07043	.1375	1.553
2.93	.1958	−0.1115	1.875
3.67	.3936	−0.2977	2.202
4.40	.7337	−0.4675	2.569

B = **KCl**; T = 298.1°K
Solid phase probably contained $PbCl_2(s)$ (611)

B = **KBr**; T = 298.1°K (1192)

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.001	0.02645	1.3714	0.283
.002	.02611	1.3718	.283
.0050	.02500	1.3734	.283
.0100	.02345	1.3732	.283
.0200	.02043	1.3737	.285
.0500	.01380	1.3594	.303
.1000	.00859	1.3097	.347
.2000	.00694	1.1661	.470
.3740	.00687	0.9955	.628

$PbI_2(s) = Pb^{++} + 2I^-$

T = 298.1°K (862)

s_A	log $(1/c_\pm)$	μ_c
0.00165	2.5818	0.0703

PbI_2.—(*Continued*)

B = HNO_3; T = 298.3°K ($^{373.5}$)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.0	0.00158	2.6006	0.0688
.001	.00165	2.5818	.0771
.01	.00184	2.5345	.1246
.051	.00223	2.4510	.240
.01*	.00223	2.4510	.240

* 0.01N HNO_3 + 0.04N KNO_3.

B = NH_4I

m_B	S_A	log $(1/m_\pm)$	$\mu^{1/2}$
T = 293.1°K (^{326})			
0.0	0.001301	2.6850	0.0625
.2532	.0006507	1.4584	.505
.4448	.000694	1.2889	.668
.5207*	.00232	1.0645	.726
T = 333.1°K (^{326})			
0.0	0.00369	2.2656	0.1052
.4462	.00319	1.0616	.676
.7593	.00360	0.8916	.878
1.0986*	.00729	.6814	1.053

* Solid phase, $PbI_2(s)$ + $PbNH_4I_3.2H_2O(s)$.

B = KI

T = 286.1°K (^{326})			
0.0	0.00108	2.766	0.0569
.1361	.0000221	2.1292	.3691
.2626	.0000226	1.8057	.5125
.6024	.0000694	1.5329	.7741
.9813	.0000755	1.3794	.9910
1.1488*	.001291	0.9222	1.0740
T = 333.1°K (^{326})			
0.0	0.00369	2.2656	0.1052
.17608	.0000434	1.9567	.3195
.6199	.000477	1.2427	.788
1.0199	.0005076	1.0922	1.011
1.2669	.003154	0.7638	1.129
1.394	.003744	.7112	1.185
1.462	.004048	.6860	1.214
1.6072	.007442	.5761	1.276
2.5885	.05748	.1253	1.661
2.7523	.08169	.0528	1.731
2.939	.1036	−0.0036	1.803

* Solid phase, $PbI_2(s)$ + $PbKI_3.2H_2O$.

$Pb(IO_3)_2(s) = Pb^{++} + 2IO_3^-$

log $(1/c_\pm^\circ)$ = 4.076

B = $Pb(NO_3)_2$; T = 298.1°K (^{573})

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$	log γ_c
0.0	0.0000551	4.0581	0.01286	−0.018
.00005	.0000435	4.0500	.01675	−0.026
.0005	.0000206	4.0186	.03952	−0.057
.005	.00000925	3.9219	.1226	−0.154
.050	.000008	3.6309	.3873	−0.445
.250	.000014	3.2359	.8660	−0.840
1.50	.000075	2.4906	2.121	−1.585

B = KIO_3; T = 298.1°K (^{573})

0.00005304	0.00003575	4.0855	0.01266	0.009
.0001061	.00002185	4.1032	.01310	.027

B = KNO_3; T = 298.1°K (^{573})

0.002	0.00005705	4.0431	0.04659	−0.033
.010	.0000667	3.9752	.1010	−0.101
.050	.0001019	3.7912	.2243	−0.285

$PbSO_4(s) = Pb^{++} + SO_4^{--}$

B = HCl; T = 291.1°K (^{71}); *cf.* (^{1235})

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.0	0.000126	3.899	0.0225
.1	.000917	3.037	.3220
.2	.00172	2.764	.4549
.3	.00267	2.573	.5575
.4	.00363	2.439	.6430

B = H_2SO_4; T = 298.1°K (^{1147}); *cf.* (^{342})

0.0	0.000126	3.899	0.0225
.00005	.000110	3.877	.0243
.0001	.000101	3.846	.0265
.00025	.000064	3.848	.0317
.0005	.000043	3.816	.0409
.005	.000017	3.535	.1228

B = HNO_3; T = 291.1°K (^{71}); *cf.* (^{1235})

0.1	0.000506	3.296	0.3193
.2	.000844	3.072	.4475
.3	.00113	2.947	.5518
.4	.00144	2.841	.6370

B = $NH_4C_2H_3O_2$, Ammonium acetate; T = 298.1°K ($^{952,\ 1090.5}$)

m_B	S_A	m_B	S_A
0.0	0.000135	0.7365	0.01962
.104	.00212	1.580	.06320
.2094	.00459	3.708	.1715
.4285	.01037		

B = NaCl; T = 291.1°K (^{71})

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.1	0.000546	3.263	0.3197
.2	.000904	3.044	.4512
.3	.00128	2.893	.5523
.4	.00163	2.775	.6377

B = $NaC_2H_3O_2$, Acetate; T = 298.1°K (^{443})

m_B	S_A	m_B	S_A
0.9098	0.02609	3.926	0.3714
1.8	.09992	4.673	.5224
2.981	.2342	2.5*	.1858

* 291 – 293°K.

B = $KC_2H_3O_2$, Acetate (^{443})

$Th(C_2O_4)_2.6H_2O(s) = Th^{++++} + 2C_2O_4^{--} + 6H_2O(l)$

B = HCl

m_B*	S_A†	m_B*	S_A†
T = 290.1°K (^{301})			
0.0	0.0000416	2.30	0.000416
.329	.0000857	3.59	.000686
.878	.0000115	4.44	.000931
.987	.0000149	5.43	.00157
1.26	.000230		
T = 333.1°K (^{301})			
0.0	0.0000416	4.42	0.00252
1.12	.000245	4.94	.00328
2.30	.000686	5.46	.00414
3.40	.00139	5.92	.00568

* *See* (^{301}) for B = HCl + $H_2C_2O_4$. † Per 1000 g solution.

B = H_2SO_4

c_B	s_A*	c_B	s_A*
T = 298.1°K (^{592})			
0.5	0.00098	2.5	0.00757
.5	.00114		

B = H_2SO_4.—(*Continued*)

c_B	s_A*	c_B	s_A*
$T = 298.1$°K (1534)			
0.25	0.000975	1.544	0.00572
.50	.001475	1.672	.00679
.725	.001703	2.113	.00938
1.08	.00416		
$T = 298.1$°K (594); *cf.* (1324)			
0.0625	0.000264	0.525	0.00158
.125	.000529	.800	.00268
.250	.000983	1.225	.00499

* Per 1000 g solution.

B = $H_2C_2O_4$, Oxalic acid; $T = 290.1$°K (301); *cf.* (594)

c_B	s_A*†	c_B	s_A*†
0.189	0.0000049	1.033	0.000024
.722	.0000171	2.556	.00073
$T = 298.1$°K (594)			
	$s_A = ThO_2$†		$s_A = ThO_2$†
0.75	0.0015	satd.	0.0030

* *See* (301) for B = $H_2C_2O_4$ + HCl at 290.1 and 323.1°K. † Per 1000 g solution.

B = $(NH_4)_2C_2O_4$, Ammonium oxalate

$T = 298.1$°K (592)			
0.005	0.00004	satd.	0.561
.05	.0083	satd.	.550
.25	.0666		
$T = 298.1$°K (594)			
0.00033	0.000050	0.00120	0.000208
.00044	.000081	.00130	.000220
.00072	.00012	.00148	.000250
.00109	.000200	.00153	.000260

$Th(C_2O_4)_2.6H_2O$(amorph.) $= Th^{++++} + 2C_2O_4^{--} + 6H_2O$

(1)

B = HCl; $T = 298.1$°K (1324)

c_B	s_A	c_B	s_A
0.25	0.0000235	1.00	0.0001084
.50	.0000438		

B = H_2SO_4; $T = 298.1$°K (1324)

0.125	0.0001109	0.5	0.0005270
.25	.0002401		

$TlCl(s) = Tl^+ + Cl^-$

$\log (1/m^\circ_\pm) = 1.8630 \pm 0.002$; $\log 1/c^\circ_\pm = -1.8630 \pm 0.002$ (1192)

B = HCl

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
$T = 298.1$°K (1075, 1076) *corrected by* (175)			
0.0	0.01607	1.7940	0.1265
.025	.008654	1.7677	.1834
.0283 (1075)	.00834	1.7575	.191
.05	.00583	1.7437	.2364
.0560 (1075)	.00564	1.7294	.248
.01	.00383	1.7002	.3215
.1468 (1075)	.00315	1.6629	.387
.2	.002534	1.6452	.450
1.00 (1075)	.00200	1.3492	1.001

B = HNO_3; $T = 298.1$°K* (629, 630)

m_B	S_A	$\log (1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0	0.01657	1.7807	0.1285
.5169	.02571	1.6899	.736
1.0804	.03092	1.5098	1.055
2.3700	.03941	1.4044	1.550
5.4512	.05625	1.2499	2.350

* The temperature is probably higher than 298.1°K.

B = NH_4Cl; $T = 298.1$°K (1075, 1076) *corrected by* (175)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.025	0.00875	1.7647	0.1835
.05	.00591	1.7404	.236
.2	.00270	1.6301	.450

B = NH_4NO_3; $T = 298.1$°K (468)

0.0	0.01606	1.7943	0.1265
.5	.02587	1.5872	.7254
1	.03121	1.5057	1.015
2	.03966	1.4016	1.428

B = $C_2H_4O_2$, Acetic acid; $T = 298.1$°K (625); *cf.* (626)

m_B	d_4^{25}	S_A	$\log (1/m_\pm)$
0.0		0.01634	1.7828
.5310	0.9986	.01639	1.7854
1.080	1.0014	.01595	1.7973
2.272	1.0085	.01495	1.8254
5.43	1.0295	.01281	1.8925
14.53	1.0521	.00960	2.0177
31.00	1.0570	.00708	2.1500
70.00	1.0614	.00605	2.2183
150.00	1.0638	.00467	2.3307
c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
$T = 298.1$°K (626)			
0.0	0.016085	1.7934	
.0501	.016027	1.7951	
.0958	.016006	1.7956	
.263	.015662	1.8052	
.524	.015258	1.8164	

B = $TlClO_3$; $T = 298.1$°K (1075) *corrected by* (175)

0.025	0.00893	1.7591	0.184

B = $TlBrO_3$; $T = 312.85$°K (1077)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.02523	1.5981	0.1588
0.01567	0.01952	1.5816	0.1876

B = Tl_2SO_4; $T = 298.1$°K (231)

m_B	S_A	$\log (1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0	0.01612	1.7926	0.1268
.02511	.00683	1.7132	.2865
.05039	.00467	1.6537	.394
c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
$T = 298.1$°K (175)			
0.0	0.01615	1.7918	0.1271
.01004	.01039	1.7497	.2012
.01415*	.00883	1.7415	.1515
.02511	.006804	1.7056	.2865
.0280*	.00624	1.7054	.185
.05029	.004708	1.6524	.394
m_B	S_A	$\log (1/m_\pm)$	$\mu^{\frac{1}{2}}$
$T = 323.1$°K (231)			
0.0	0.03341	1.4761	0.1827
.02542	.02095	1.4114	.3112
.05076	.01591	1.3643	.4100

* From (1075) corrected by (175).

B = $TlNO_3$; $T = 298.1$°K (231)

0.0	0.01612	1.7926	0.1268
.05035	.00619	1.7284	.237
.10075	.00416	1.6851	.324
.20284	.00304	1.6017	.453

$TlCl$.—(*Continued*)

B = $TlNO_3$.—(*Continued*)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
T = 298.1°K (1075) *corrected by* (175)			
0.0	0.01607	1.7940	0.1266
.0283	.00828	1.7584	.1905
.0560	.00570	1.7269	.248
.1468	.00331	1.6519	.387
m_B	S_A	log $(1/m_\pm)$	$\mu^{1/2}$
T = 298.1°K (1076) *corrected by* (175)			
0.0	0.01607	1.7940	0.1265
.025	.0088	1.7633	.1838
.05	.00624	1.7274	.2371
.1	.00422	1.6783	.3228
T = 323.1°K (231)			
0.0	0.03341	1.4761	0.1827
.10167	.01404	1.3947	.340
.20481	.01034	1.3264	.463

B = $TlCNS$

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
T = 298.1°K (1075)			
0.0	0.01607	1.7940	0.1265
.0107	.0119	1.7844	.1503
T = 312.84°K (1077)			
0.02149	0.01807	1.7430	0.1989

B = $ZnCl_2$; T = 298.1°K (1076) *corrected by* (175)

0.0	0.01607	1.7940	0.1265
.0125	.00896	1.7584	.215
.025	.00625	1.7270	.285
.05	.00411	1.6844	.392
.1	.00280	1.6229	.550

B = $ZnSO_4$

m_B	S_A	log $(1/m_\pm)$	$\mu^{1/2}$
T = 273.1°K (231)			
0.0	0.006701	2.1739	0.0819
.04997	.008746	2.0582	.457
.1	.009786	2.0094	.639
.2998	.01213	1.9161	1.100
5986	.01421	1.8474	1.552
T = 298.1°K (231)			
0.0	0.01612	1.7926	0.1268
.05013	.02065	1.6851	.470
.10021	.02284	1.6413	.650
.30045	.02773	1.5571	1.108
.60062	.03209	1.4936	1.559
T = 323.1°K (231)			
0.0		1.4761	0.1827
.05066	0.04081	1.3892	.4935
.10142	.04520	1.3448	.6712
.3047	.05432	1.2650	1.1285
.6093	.06265	1.2031	1.5810

B = $CdCl_2$; T = 298.1°K (1076) *corrected by* (175)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.0	0.01607	1.1940	0.1265
.0125	.01037	1.7178	.218
.025	.00778	1.6736	.287
.05	.00576	1.6076	.394
.1	.00426	1.5302	.551

B = $CdSO_4$; T = 298.1°K (1075) *corrected by* (175)

0.015	0.0206	1.5665	0.1887
.03935	.0254	1.3912	.2545
.0787	.0309	1.2343	.3311

B = $CuCl_2$; T = 298.1°K (1076) *corrected by* (175)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.0	0.01607	1.7940	0.1268
.0125	.00903	1.7562	.215
.025	.00612	1.7321	.285
.05	.00421	1.6789	.392
.1	.00290	1.6144	.550

B = $MnCl_2$; T = 298.1°K (1076) *corrected by* (175)

0.0	0.01607	1.7940	0.1268
.0125	.00895	1.7587	.215
.025	.00615	1.7309	.285
.05	.00411	1.6894	.392
.1	.00285	1.6189	.550

B = $FeCl_2$; T = 298.1°K (569)

(569) states same solubility as in $BaCl_2$ (175)

B = $La_2(SO_4)_3$

m_B	S_A	log $(1/m_\pm)$	$\mu^{1/2}$
T = 273.1°K (231)			
0.0	0.00670	2.1739	0.0819
.01001	.00747	2.1267	.3965
.01502	.00806	2.0937	.482
.02005	.00830	2.0809	.555
.02507	.00847	2.0721	.620
T = 298.1°K (231)			
0.0	0.01612	1.7926	0.1268
.01004	.01809	1.7433	.410
.01508	.01845	1.7352	.484
.02012	.01925	1.7176	.566
.02516	.01950	1.7120	.630

B = $La(NO_3)_3$; T = 298.1°K (1174)

m_B	S_A	log $(1/m_\pm)$	$\mu^{1/2}$
0.0	0.01611	1.7929	0.1269
.005215	.01740	1.7594	.2224
.008808	.01778	1.7500	.2657
.02024	.01946	1.7109	.3754
.04180	.02129	1.6718	.5216
.08166	.02433	1.6138	.7171
.1970	.02697	1.5692	1.100

B = $MgCl_2$; T = 298.1°K (1076) *corrected by* (175)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.0	0.01607	1.7940	0.1265
.0125	.00901	1.7559	.147
.025	.00616	1.7297	.176
.05	.00412	1.6882	.233
.10	.00274	1.6268	.320

B = $MgSO_4$; T = 298.1°K (1174)

m_B	S_A	log $(1/m_\pm)$	$\mu^{1/2}$
0.0	0.01611	1.7929	0.1269
.01708	.01920	1.7127	.2958
.03364	.02042	1.6899	.3937
.04384	.02106	1.6765	.4454
.06259	.02214	1.6548	.5220
.1291	.02504	1.6014	.7358
.1994	.02641	1.5782	.9078
.3529	.02878	1.5409	1.2002

B = $CaCl_2$; T = 298.1°K (1076) *corrected by* (175)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.0	0.01607	1.7940	0.1265
.0125	.00893	1.7593	.215
.025	.00622	1.7281	.285
.05	.00416	1.6867	.392
.1	.00283	1.6206	.550

B = $BaCl_2$; *T* = 298.1°K (1076) *corrected by* (175)

c_B	s_A	$\log(1/c_\pm)$	$\mu_c^{1/2}$
0.0	0.01607	1.7940	0.1265
.01415*	.00855	1.7508	.226
.025	.00618	1.7297	.285
.05	.00424	1.6772	.393
.0734*	.00322	1.6580	.472

* (1075).

B = $LiNO_3$; *T* = 298.1°K (468)

0.0	0.01606	1.7943	0.1265
.5	.02542	1.5948	.7249
1	.03035	1.5178	1.015
2	.03785	1.4219	1.427
3	.04438	1.3528	1.744

B = $NaCl$; *T* = 298.1°K (1076) *corrected by* (175)

0.0	0.01607	1.7940	0.1265
.025	.00867	1.7669	.1835
.05	.00590	1.7408	.236
.1	.00394	1.6989	.322
.2	.00270	1.6308	.450

B = $NaClO_3$; *T* = 298.1°K (468)

0.0	0.01606	1.7943	0.1265
.5	.02320	1.6345	.7233
1	.02687	1.5707	1.1425
2	.03060	1.5142	1.425
3	.03303	1.4810	1.7415
4	.03850	1.4145	2.01

B = $NaNO_3$; *T* = 298.1°K (468)

0.0	0.01606	1.7943	0.1265
.5	.02564	1.5910	.725
1	.03054	1.5151	1.014
2	.03851	1.4144	1.428
3	.04544	1.3425	1.745
4	.05128	1.2900	2.013

B = $NaC_2H_3O_2$, Acetate; *T* = 298.1°K (1075) *corrected by* (175)

0.0	0.01607	1.7940	0.1265
.0150	.0163	1.7878	.177
.0300	.0169	1.7721	216
.0787	.0181	1.7423	311
.1574	.0192	1.7167	.420

B = KCl; *T* = 298.1°K (231)

m_B	S_A	$\log(1/m_\pm)$	$\mu^{1/2}$
0.0	0.01612	1.7926	0.1265
.05025	.00589	1.7403	.237
.10051	.00389	1.6957	.322
.20190	.00260	1.6372	.451
.50911	.00179	1.5194	.714

c_B	s_A	$\log(1/c_\pm)$	$\mu_c^{1/2}$
T = 298.1°K (1075) *corrected by* (175); *cf.* (199)			
0.0	0.01607	1.7940	0.1265
.025	.00869	1.7667	.1835
.05	.00590	1.7408	.2364
.1	.00396	1.6927	.3224
.2	.00268	1.6325	.4502
.8	.00170	1.4237	.8954

m_B	S_A	$\log(1/m_\pm)$	$\mu^{1/2}$
T = 323.1°K (231)			
0.0	0.033412	1.4761	0.1827
.05071	.01861	1.4448	.2633
.10151	.01300	1.4136	.3384
.2036	.00909	1.3568	.4612
.5140	.00623	1.2447	.7211

B = $KClO_3$; *T* = 298.1°K (468)

c_B	s_A	$\log(1/c_\pm)$	$\mu_c^{1/2}$
0.5	0.5237	1.6252	0.7237

B = K_2SO_4; *T* = 298.1°K (175)

m_B	S_A	$\log(1/m_\pm)$	$\mu^{1/2}$
0.0	0.01615	1.7918	0.1271
.01006	.01787	1.7479	.2002
.02511	.01953	1.7093	.314
.05028	.02151	1.6674	.415
.1515	.02628	1.5814	.686
.5133	.03512	1.4544	1.255

B = KNO_3

T = 273.1°K (231)			
0.0	0.006701	2.1739	0.0819
.0501	.007894	2.1027	.2405
.2015	.009623	2.0167	.459
5094	.01206	1.9191	.721
1.0401	.015310	1.8150	1.025
T = 298.1°K (231)			
0.0	0.01612	1.7926	0.1268
.05028	.01836	1.7361	.262
.20234	.02176	1.6623	.473
.51228	.02619	1.5819	.733
1.0487	.03178	1.4979	1.040
T = 298.1°K (175); *cf.* (199)			
0.0	0.01615	1.7918	0.127
.0201	.01725	1.7632	.193
.0503	.01838	1.7467	.262
.1008	.01977	1.7040	.347
.3080	.02375	1.6243	.575
1.047	.03217	1.4925	1.037

c_B	s_A	$\log(1/c_\pm)$	$\mu_c^{1/2}$
T = 298.1°K (468)			
0.0	0.01606	1.7943	0.1265
.5	.02566	1.5907	.725
1.0	.03077	1.5119	1.019
2	.03904	1.4085	1.428
T = 298.1°K (1075) *corrected by* (175)			
0.015	0.0170	1.7695	0.1789
.03	.0179	1.7471	.2189
.0787	.0192	1.7167	.3129
.1574	.0212	1.6736	.4226

m_B	S_A	$\log(1/m_\pm)$	$\mu^{1/2}$
T = 323.1°K (231)			
0.0	0.03341	1.4761	0.1827
.05075	.03652	1.4375	.295
.20435	.04226	1.3741	.495
.51797	.04966	1.3040	.753
1.06067	.05859	1.2322	1.052

$TlClO_3$ (s) = $Tl^+ + ClO_3^-$

B = Tl_2SO_4; *T* = 293.1°K (1078)

c_B	s_A	$\log(1/c_\pm)$	$\mu_c^{1/2}$
0.0	0.1340	0.8729	0.3611
.0683	.1058	.5889	.5574

$TlBr(s) = Tl^+ + Br^-$

B = $TlNO_3$; T = 341.6°K (1075)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00869	2.0609	0.09311
.0163	.00410	2.0387	.1428
.0294	.00289	2.0150	.1797
.0995	.00148	1.9127	.3178

$TlBrO_3(s) = Tl^+ + BrO_3^-$

B = TlCl; T = 312.85°K (1077)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.02216	1.6544	0.1489
0.01952*	0.01567	1.6292	0.1876

* TlCl(s) present.

B = TlCNS; T = 312.85°K (1077)

0.02210*	0.01496	1.6280	0.1925

* TlCNS (s) present.

$TlCNS(s) = Tl^+ + CNS^-$

B = TlCl

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
T = 298.1°K (1075)			
0	0.0149	1.8286	0.1221
0.0119*	.0107	1.8082	.1503
T = 312.85°K (1077)			
0.0	0.02773	1.5570	0.1665
.01807*	0.03956	1.5452	.1989

* TlCl(s) present.

B = $TlBrO_3$; T = 312.85°K (1077)

$0.01496_{satd.}$	0.03706*	1.5433	0.1925

* $TlBrO_3$(s) present.

B = $TlNO_3$; T = 298.1°K (1075)

0.0	0.0149	1.8286	0.1221
.0227	.00852	1.7875	.1767
.0822	.00406	1.7278	.2937

B = KCNS; T = 298.1°K (1075)

0.0227	0.0083	1.7947	0.1761

$Tl_2SO_4(s) = 2Tl^+ + SO_4^{--}$

B = H_2SO_4; T = 298.1°K (1078)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.1083	0.7646	0.570
.0247	.1172	.7027	.652
.04935	.1249	.6545	.723

B = $TlClO_3$; T = 293.1°K (1078)

0.0	0.0964	0.8152	0.538
.1058	.0683	.7988	.558

B = $TlNO_3$; T = 298.1°K (1078)

0.0996	0.08365	0.7416	0.593

B = $NaHSO_4$; T = 298.1°K (1078)

0.0505	0.1161	0.6821	0.707

B = Na_2SO_4; T = 298.1°K (1078)

0.02485	0.1080	0.7359	0.632

$Tl_2C_2O_4(s)$, Oxalate $= 2Tl^+ + C_2O_4^{--}$

B = $TlNO_3$; T = 298.1°K (9)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.03768	1.2232	0.336
.04114	.0264	1.2108	.347
.0799	.0195	1.1865	.372
.1597	.01235	1.1256	.444

B = $K_2C_2O_4$; T = 298.1°K (9)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0498	0.0351	1.1261	0.505
.0996	.03565	1.0541	.637
.2467	.0390	0.9199	.926
.4886	.04506	.7877	1.262
.9785	.05536	.6324	1.763

AgCl (s) $= Ag^+ + Cl^-$

B = HCl, B = HNO_3 and B = Various salts; *see* p. 266

AgBr (s) $= Ag^+ + Br^-$

B = $Hg(NO_3)_2$ and B = KBr; *see* p. 267

$AgBrO_3$ (s) $= Ag^+ + BrO_3^-$

log $1/m_\pm^\circ = 2.142 \pm 0.003$

B = $C_2H_4O_2$, Acetic acid; T = 298.1°K (626)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.008267	2.0827	0.09092
.0498	.008240	2.0840	
.0997	.008219	2.0851	
.1995	.008145	2.0891	
.4988	.007904	2.1022	
.9975	.007639	2.1169	
1.8721	.006861	2.1636	

B = $CdSO_4$; T = 298.1°K (317)

0.0	0.008062	2.0937	0.0898
.1	.01041	1.9828	.6406
.5	.01335	1.8745	1.419

B = $AgNO_3$; T = 297.6°K (1075)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00810	2.0915	0.0900
.00850	.00510	2.0794	.1167
.0346	.00216	2.0500	.1917

B = $Ce(NO_3)_3$; T = 298.1°K (317)

0.0125	0.008888	2.0512	0.2835
.025	.009336	2.0298	.3992

B = $MgSO_4$; T = 298.1°K (317)

0.02	0.00892	2.0497	0.2212
.051	.00967	2.0143	.4622
.1	.0103	1.9872	.6406
.1988	.01138	1.9439	.8981

B = $Mg(NO_3)_2$; T = 298.1°K (317)

0.025	0.008935	2.0489	0.2897
.05	.009414	2.0263	.3983
.10	.01009	1.9961	.5576

B = $Ba(NO_3)_2$; T = 298.1°K (317)

0.025	0.009088	2.0415	0.2900
.05	.009655	2.0153	.3995
.10	.010373	1.9841	.5571

B = Na_2SO_4; T = 298.1°K (317)

0.05	0.009965	2.0015	0.400
.10	.01097	1.9597	.5706
1.00	.01862	1.7300	1.737

B = $KClO_4$; T = 298.1°K (317)

0.025	0.008716	2.0596	0.1836
.05	.009190	2.0367	.2433
.10	.009706	2.0129	.3312

B = $KBrO_3$; T = 297.6°K (1075)

0.00850	0.00519	2.0742	0.117
.0346	.00227	2.0386	.192

B = $\mathbf{K_2SO_4}$; T = 298.1°K (317)

c_B	s_A	log $(1/c_{\pm})$	$\mu_c^{\frac{1}{2}}$
0.025	0.00929	2.0159	0.2903
.05	.01002	1.9994	.400
.1	.01109	1.955	.5577
B = $\mathbf{KNO_3}$; T = 298.1°K (317)			
0.040	0.00912	2.0400	0.2221
.100	.00992	2.0035	.3303
.200	.01106	1.9562	.4594
.394	.01266	1.8976	.6377

$\mathbf{AgI}$ (s) = $\mathbf{Ag^+ + I^-}$

B = $\mathbf{Hg(NO_3)_2}$ and B = $\mathbf{AgNO_3}$; *see* p. 268

$\mathbf{AgIO_3(s) = Ag^+ + IO_3^-}$

$s_A = 1.89 \times 10^{-4}$ (1084)

log $(1/m^{\circ}_{\pm})(298.1) = 3.762 \pm 0.003$; $K_{298.1} = 5.29 \times 10^{-8}$

B = $\mathbf{HNO_3}$; T = 298.1°K (629, 630)

c_B	s_A	log $(1/c_{\pm})$	$\mu_c^{\frac{1}{2}}$
0.0	0.000178	3.7496	0.01334
.125	.000304	3.5171	.354
.25	.000379	3.4214	.5004
.5	.000499	3.302	.7075
1.0	.000731	3.136	1.001
2.0	.001174	2.930	1.415
4.0	.002469	2.6075	2.000
8.0	.005608	2.2511	2.829

$\mathbf{AgNO_2}$ (s) = $\mathbf{Ag^+ + NO_2^-}$

log $(1/m^{\circ}_{\pm})(298.1)$ = 1.850 from $K_{298 \cdot 1} = 2.0 \times 10^{-4}$ (6) *from* (5, 892, 1049, 1050)

B = $\mathbf{AgNO_3}$

c_B	s_A	log $(1/c_{\pm})$	$\mu_c^{\frac{1}{2}}$
T = 298.1°K (313)			
0.0	0.0269	1.5702	0.164
.00258	.0260	1.5644	.169
.00588	.0244	1.5657	.174
.01177	.0224	1.558	.185
.02355	.0192	1.542	.207
.04710	.0164	1.4913	.252
T = 291.1°K (1049)			
0.0	0.02067	1.6846	0.1438
.00258	.01975	1.6777	.1494
.00517	.01900	1.6689	.1555
.01033	.01689	1.6687	.1650
.02067	.01435	1.6494	.1871
04134	.01168	1.6040	.2303
.08268	.00961	1.5270	.3038
B = $\mathbf{KNO_2}$; T = 298.1°K (313)			
0.00258	0.0259	1.5660	0.1688
.00588	.0249	1.5577	.1754
.01177	.0232	1.5454	.187
.02355	.0203	1.5252	.2094
.04710	.0181	1.4640	.2552

$\mathbf{AgC_2H_3O_2}$, Acetate = $\mathbf{Ag^+ + C_2H_3O_2^-}$

B = $\mathbf{C_2H_4O_2}$, Acetic acid; T = 298.1°K (769)

c_B	s_A	log $(1/c_{\pm})$	$\mu_c^{\frac{1}{2}}$
0.0	0.06635	1.1782	0.2576
1	.0643	0.5823	
2	.0618	.4474	
2.98	.0598	.3702	
4.19	.0570	.3089	
5.99	.0532	.2464	

B = $\mathbf{C_2H_4O_2}$.—(*Continued*)

c_B	s_A	log $(1/c_{\pm})$	$\mu_c^{\frac{1}{2}}$
8.01	0.0463	0.2140	
9.96	.0406	.1956	
12.32	.0319	.2022	
13.97	.0257	.2221	
14.96	.0206	.2558	
15.93	.0149	.3127	
17.28	.00653	.4736	
B = $\mathbf{Pb(C_2H_3O_2)_2}$, Acetate; T = 298.1°K (677)			
0.0	0.0667	1.1759	0.2583
.01	.06403	1.1346	.3067
.05	.0566	1.0262	.4545
.1	.04995	0.9518	.5916
.5	.04349	.6715	1.242
1.0	.03587	.5711	1.743
B = $\mathbf{Cd(C_2H_3O_2)_2}$, Acetate; T = 298.1°K (677)			
0.01	0.06224	1.1454	0.3037
.05	.04852	1.0711	.4455
.1	.04021	1.0075	.583
.5	.02592	0.7876	1.235
1.0	.02363	.6601	1.739
B = $\mathbf{AgNO_3}$			
T = 289.1°K (1051)			
0.0	0.0603	1.2196	0.2484
.061	.0417	1.1841	.3205
.119	.0341	1.1411	.3913
.230	.0195	1.1564	.4995
T = 292.9°K (26)			
0.0	0.0590	1.2291	0.2429
.0533	.0411	1.2056	.3072
.1	.0311	1.1948	.3621
T = 298.1°K (677)			
0.01634	0.0595	1.1728	0.2754
.03268	.0540	1.1648	.2944
.06535	.0444	1.1561	.3312
.1307	.0348	1.1199	.4063
B = $\mathbf{NaC_2H_3O_2}$, Acetate; T = 289.1°K (1051)			
0.061	0.0392	1.2029	0.3597
.119	.0280	1.1927	.3834
.230	.0208	1.1412	.5010
T = 289.1°K (1049)			
0.0	0.0569	1.2448	0.2385
.0569	.03748	1.2256	.3072
.1138	.02787	1.2018	.3764
.2276	.01973	1.1558	.4973
T = 291.7°K (26)			
0.0	0.0593	1.2269	0.2435
.0333	.0474	1.2087	.2841
.0667	.0384	1.1970	.3242
.1333	.0282	1.1708	.4018
.2667	.0203	1.1173	.5357
.5000	.0147	1.0605	.7173
T = 298.1°K (677)			
0.0240	0.05557	1.1771	0.2821
.2403	.02519	1.0874	.5153
1.201	.01396	0.8853	1.102
2.403	.01239	.7620	1.554
B = $\mathbf{KC_2H_3O_2}$, Acetate; T = 298.1°K (677)			
0.0226	0.0575	1.1973	0.2648
.2262	.02653	1.0868	.5027
1.131	.01442	0.8911	1.070
2.262	.01305	.7637	1.510

$AgC_2H_2ClO_2(s)$, Chloroacetate = $Ag^+ + C_2H_2ClO_2^-$

B = HNO_3; T = 298.1°K (629, 630)

c_B	s_A	d	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.0	0.0737	1.0095	1.1325	0.2715
.2405	.2546	1.0426	0.5941	.7036
.4738	.4560	1.0791	0.3410	.9642
.9525	.8309	1.1473	0.0904	1.335
1.751	1.543	1.2716	−0.1884	1.815
3.271	2.726	1.4749	−0.4355	2.449
3.918	3.273	1.5673	−0.5149	2.644

B = $AgNO_3$; T = 290.0°K (26)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.0	0.0644	1.1911	0.2538
.0533	.0449	1.1567	.329
.1	.0373	1.1453	.3705

B = $NaC_2H_2ClO_2$, Chloroacetate; T = 290.0°K (26)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.0333	0.0499	1.1909	0.2885
.0667	.0405	1.1812	.3274
.1333	.0299	1.1557	.404
.2667	.0208	1.1112	.5362
.5	.0162	1.0388	.7185

$AgC_3H_5O_2(s)$, Propionate = $Ag^+ + C_3H_5O_2^-$

B = $C_3H_6O_2$, Propionic acid; T = 298.1°K (769)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0	0.04782	1.3203	0.2187
1	.04539	0.6618	1.022
2	.04237	.5313	1.429
2.97	.04020	.4586	1.735
4.95	.03587	.3738	2.233
6.97	.03057	.3347	2.646
8.56	.02623	.3240	2.929
11.40	.01671	.3597	3.380
13.03	.01148	.4154	3.611

B = $AgNO_3$; T = 292.8°K (26)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.0	0.0462	1.3353	0.2150
.0167	.0393	1.3286	.2366
.0333	.0345	1.3154	.2604
.0667	.0258	1.3064	.3074
.1333	.0191	1.2679	.3904
.2667	.0131	1.2179	.5290
.5000	.0101	1.1440	.7142

B = $NaC_3H_5O_2$, Propionate; T = 291.1°K (26)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.0	0.0471	1.3269	0.217
.0133	.0415	1.3653	.2117
.0267	.0379	1.3056	.2542
.0533	.0307	1.2943	.2898
.1	.0222	1.2832	.3496

$AgC_4H_7O_2$, Butyrate = $Ag^+ + C_4H_7O_2^-$

B = $AgNO_3$; T = 291.9°K (26)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.0	0.0228	1.6420	0.151
.0667	.0078	1.6179	.273
.1	.0062	1.5907	.3257

B = $AgC_2H_3O_2$, Acetate; T = 290.9°K (26)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.0	0.0221	1.6556	0.1486
.0270	.0139	1.6226	.2022
.0506	.0103	1.6013	.2468

B = $NaC_4H_7O_2$, Butyrate; T = 291.3°K (26)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.0	0.0224	1.6497	0.1497
.0066	.0199	1.6389	.1628
.0164	.0169	1.6252	.1825
.0329	.0131	1.6099	.2145
.0658	.0091	1.5832	.2675
.1315	.0060	1.5417	.3708
.263	.0040	1.4857	.5167
.493	.0027	1.4367	.6953

$AgC_5H_9O_2$, Valerate = $Ag^+ + C_5H_9O_2^-$

B = $AgNO_3$; T = 289.6°K (26)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.0	0.0094	2.0268	0.0969
.0067	.0068	2.0185	.1162
.01333	.0051	2.0134	.1358
.0267	.0031	2.0171	.1726
0.1	.0012	1.9578	.3181

B = $AgC_2H_3O_2$, Acetate; T = 290.9°K (26)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.0	0.0094	2.0268	0.0969
.0067	.0070	2.0091	.1170
.0135	.0057	1.9804	.1386
.0270	.0037	1.9723	.1752
.0505	.00265	1.9257	.2305

B = $NaC_5H_9O_2$, Valerate; T = 291.7°K (26)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.0	0.0095	2.0223	0.0975
.0175	.0047	1.9908	.1486
.0349	.0030	1.9721	.1947
.0698	.0018	1.9448	.2676
.1395	.0015	1.9373	.3755

$AgC_7H_5O_2$, Benzoate = $Ag^+ + C_7H_5O_2^-$

B = HNO_3; T = 298.1°K (1086)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.0	0.01144	1.9416	0.1070
.004435	.01395	1.8557	.1356
.00887	.01698	1.7700	.1608
.008915	.01715	1.7657	.1614
.01774	.02324	1.6337	.2024
.01783	.02351	1.6287	.2034
.02674	.03071	1.5127	.2397

B = $C_2H_3ClO_2$, Chloroacetic acid; T = 298.1°K (1086)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.003935	0.01385	1.8585	
.00785	.01612	1.7926	
.01574	.02093	1.6792	

$Ag_2SO_4(s) = 2Ag^+ + SO_4^{--}$

B = H_2SO_4; T = 298.1°K (1415); *cf.* (354)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.0	0.02699	1.3681	0.2949
.01451	.02744	1.2995	.3389
.02901	.02782	1.2515	.4365
.05263	.02841	1.1941	.4930

B = HNO_3; T = 298.1°K (1415)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{1/2}$
0.01589	0.02993	1.3233	0.3251
.03178	.3266	1.2853	.3603
.06357	.3795	1.2201	.4212

m_B	S_A	d	log $(1/m_\pm)$	$\mu^{1/2}$
T = 298.1°K (629, 630)				
0.0	0.02684	1.0054	1.3705	0.2838
1.043	.1138	1.0610	0.7432	1.177
2.163	.1688	1.1069	.5718	1.634

B = HNO_3.—(*Continued*)

m_B	S_A	d	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
4.568	0.2633	1.1871	0.3788	2.315
4.861	.2754	1.1956	.3593	2.385
6.764	.3317	1.2456	.2786	2.785
10.423	.3803	1.3326	.2191	3.400
15.311	.4515	1.3676	.1446	4.082

B = $(NH_4)_2SO_4$

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
$T = 289.6$°K (53)			
0.7522	0.02851	0.8651	1.530
1.468	.03492	.7929	2.124
2.206	.03903	.6213	2.595
2.944	.040825	.5670	2.994
3.634	.04162	.5313	3.320
4.26	.04137	.5103	3.592
5.0386	.04015	.4949	3.903
5.51	.03919	.4821	4.080
$T = 304.1$°K (53)			
0.0	0.02941	1.3307	0.2970
.7438	.03531	0.8035	1.529
1.46	.04269	.6534	2.123
2.204	.04811	.5603	2.599
2.898	.05083	.5053	2.974
3.448	.05192	.4744	3.391
4.344	.05218	.4406	3.623
5.066	.05131	.4228	
5.922	.04993	.4083	4.233
$T = 324.1$°K (53)			
0.0	0.03441	1.2626	0.3212
.7505	.04369	0.7391	1.543
1.5007	.05388	.5811	2.160
2.243	.06052	.4906	2.628
3.006	.0635	.4350	3.035
3.689	.0661	.3942	3.357
3.829	.06719	.3805	3.463
5.015	.06677	.3475	3.905
5.769	.06590	.3313	4.184
6.442	.06497	.3196	4.418
$T = 348.1$°K (53)			
0.0	0.04018	1.1953	0.3471
.7316	.06193	0.6382	1.540
1.395	.08364	.4609	2.106
2.244	.1062	.3250	2.650
3.098	.127	.2252	3.110
3.715	.1389	.1755	3.400
5.109	.1615	.0866	3.976
6.644	.182	.0145	4.525
6.943	.1838	.0054	4.624
$T = 373.1$°K (53)			
0.0	0.04531	1.1607	0.3612
0.7885	.08043	0.5484	1.615
1.378	.1022	.4230	2.098
2.223	.1316	.2628	2.658
2.933	.153	.1797	3.043
4.299	.1912	.0609	3.670
5.091	.2102	.0094	3.987
6.425	.2377	−0.0592	4.471
7.28	.2505	−0.0921	4.754

B = $AgNO_3$; $T = 298.1$°K (570)

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0	0.02684	1.3705	0.2838
.02501	.01958	1.3645	.2894
.05009	.01429	1.3511	.3049
.1002	.00853	1.3102	.3546

B = $MgSO_4$; $T = 298.1$°K (570)

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.01004	0.02619	1.3341	0.3587
.02511	.02555	1.2927	.4208
.05019	02506	1.2412	.5253
.10027	.02489	1.1722	.6897

B = $Mg(NO_3)_2$; $T = 298.1$°K (570)

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.01245	0.02989	1.3237	0.3564
.02500	.03243	1.2883	.4151
.05038	.03683	1.2331	.5115

B = Na_2SO_4

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
$T = 287.6$°K (51)			
0.0	0.02358	1.4267	0.2660
.3715	.02376	1.0164	1.089
.7112	.02899	0.8680	1.490
.9183	.03217	.8017	1.689
$T = 291.1$°K (53)			
0.0	0.02456	1.4091	0.2714
.0176	.02283	1.3580	.3483
.0359	.02187	1.3188	.4163
.05209	.02165	1.2865	.4703
.07039	.02133	1.2591	.5246
.1042	.02149	1.2113	.6140
.176	.02210	1.1374	.7709
.214	.02254	1.1061	.8423
.3513	.02463	1.0132	1.061
.711	.02989	0.8590	1.491
.9179	.03297	.7945	1.689
$T = 304.1$°K (53)			
0.0176	0.02761	1.2868	0.3682
.0359	.02678	1.2484	.4343
.05279	.02646	1.2179	.4876
.1056	.02629	1.1461	.6290
.1746	.02723	1.0743	.7780
.3759	.03117	0.9002	1.105
.7075	.03688	.7975	1.494
1.0686	.04233	.6996	1.826
1.789	.04964	.5806	2.349
2.776	.04689	.5350	2.770
3.307	.02989	.6460	3.164
$T = 324.1$°K (53)			
0.0176	0.0331	1.2495	0.3494
.03449	.03239	1.1839	.4479
.04787	.03207	1.1609	.4897
.0718	.03191	1.1247	.5578
.1063	.03213	1.0809	.6381
.1732	.03316	1.0041	.7867
.2780	.03537	0.9348	.9696
.7117	.04422	.7427	1.506
1.773	.05731	.5396	2.343
2.473	.05538	.5049	2.734
3.130	.02828	.6651	3.078
$T = 348.1$°K (53)			
0.01408	0.03896	1.166	0.3989
.03308	.03874	1.1217	.4642
.0563	.03868	1.0851	.5337
.06899	.03880	1.0625	.5687
.107	.03919	1.0155	.6623

Ag_2SO_4.—(*Continued*)

B = Na_2SO_4.—(*Continued*)

m_B	S_A	$\log(1/m_\pm)$	$\mu^{\frac{1}{2}}$
T = 348.1°K.—(*Continued*)			
0.176	0.04069	0.9476	0.8063
.378	.04676	.8100	1.129
.6906	.05442	.6847	1.495
1.406	.06202	.5487	2.099
1.799	.06933	.4813	2.367
2.911	.03707	.5968	2.974
T = 373.1°K (53)			
0.0352	0.04300	1.0792	0.4843
.0711	.04371	1.0189	.5869
.1014	.04432	0.9804	.6611
.1366	.04547	.9407	.7391
.2126	.04791	.8727	.8840
.3752	.05295	.7425	1.259
.7145	.06452	.6289	1.529
1.093	.07414	.5302	1.871
1.792	.0754	.4574	2.367
2.091	.07248	.4475	2.547
2.827	.03714	.2671	2.941

B = KNO_3; T = 298.1°K (570)

m_B	S_A	$\log(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.02502	0.02898	1.3372	0.3450
.05006	.03075	1.3115	.3772
.1016	.03456	1.2609	.4531

B = $KHSO_4$; T = 298.1°K (1415)

c_B	s_A	$\log(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.02632	0.02609	1.2818	0.3964
.05263	.02588	1.2238	.4853

B = K_2SO_4

m_B	S_A	$\log(1/m_\pm)$	$\mu^{\frac{1}{2}}$
T = 287.6°K (53)			
0.1911	0.02203	1.1277	0.7996
.3460	.02511	1.0096	1.055
.5251	.02877	0.9122	1.289
.5939	.03037	.8792	1.369
T = 298.1°K (570)			
0.01256	0.02543	1.3359	0.3375
.02513	.02478	1.3041	.3865
.05025	.02414	1.2537	.4725
.1007	.02432	1.1763	.6124

c_B	s_A	$\log(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
T = 298.1°K (1415)			
0.01359	0.02545	1.3316	0.3424
.02717	.02465	1.2999	.3943

m_B	S_A	$\log(1/m_\pm)$	$\mu^{\frac{1}{2}}$
T = 304.1°K (53)			
0.1926	0.02885	1.0440	0.4416
.3451	.03226	0.9346	1.064
.5302	.03701	.8358	1.304
.6749	.04047	.7762	1.465
.7776	.04336	.7365	1.569
T = 324.1°K (53)			
0.1957	0.03499	0.9823	0.8319
.3451	.03874	.8691	1.073
.5335	.04426	.7813	1.316
.6839	.04875	.7184	1.486
.8843	.05445	.6511	1.678
.9801	.05811	.6177	1.765

B = K_2SO_4.—(*Continued*)

m_B	S_A	$\log(1/m_\pm)$	$\mu^{\frac{1}{2}}$
T = 348.1°K (53)			
0.1873	0.04270	0.9550	0.758
.3540	.04855	.8079	1.099
.5371	.05535	.7130	1.333
.6892	.06080	.6517	1.500
.8889	.06821	.5830	1.695
1.0364	.07559	.5470	1.826
1.210	.08011	.4933	1.967
T = 373.1°K (53)			
0.1945	0.05009	0.8700	0.8566
.3466	.05791	.7552	1.102
.5408	.0676	.6512	1.351
.7483	.07831	.5642	1.575
.9342	.08758	.5014	1.751
1.048	.09364	.4659	1.850
1.257	.1037	.4118	2.020
1.354	.109	.3859	2.095

$Ag_2C_2O_4(s)$, Oxalate = $2Ag^+ + C_2O_4^{--}$

B = HNO_3; T = 298.1°K (629, 630)

c_B	s_A	$d_{298.1}$
0.2513	0.008853	1.008
.5025	.01411	1.0186
.9608	.02449	1.0339
1.925	.04720	1.0647
3.986	.1192	1.1415
5.534	.1998	1.1996
5.829	.2230	1.2162

$Ag_2S.AgNO_3(s) = 3Ag^+ + S^{--} + NO_3^-$

B = $AgNO_3$; *see* p. 273

$AuI\ (s) = Au^+ + I^-$

B = KI; *see* p. 273

$MnC_2O_4.2H_2O(s)$, Oxalate = $Mn^{++} + C_2O_4^{--} + 2H_2O(l)$

B = H_2SO_4; T = 298.1°K (593)

m_B	S_A	$\log(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0125	0.0128	1.8928	0.2978
.025	.0195	1.7099	.3912
.050	.0317	1.4989	.5261
.124	.0619	1.2083	.7872
.245	.1048	0.9796	1.074
.478	.1815	.7411	1.470
.696	.2482	.6052	1.726
.884	.3080	.5114	1.971
.989	.3376	.4716	2.078
1.079	.3572	.4470	2.160
B = $H_2C_2O_4$, Oxalic acid; T = 298.1°K (593)			
0.0125	0.00530	2.0126	0.2423
.025	.0065	1.8443	.3178
.05	.00755	1.6810	.4245
.125	.00976	1.4405	.6426
.25	.0119	1.2524	.8931
.49	.0145	1.0679	1.236
B = $(NH_4)_2C_2O_4$, Oxalate; T = 298.1°K (593)			
0.005	0.00237	2.3788	0.1565
.025	.00335	2.0089	.2973
.05	.00562	1.7525	.4153
.125	.0125	1.3823	.6519

B = $(NH_4)_2C_2O_4$.—*(Continued)*

m_B	S_A	$\log (1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.245	0.0278	1.0600	0.9198
.245	.0280	1.0583	.9203
.281	.0325	0.9959	.9904

$[CoCl_2(NH_3)_4]Br(s) = [CoCl_2(NH_3)_4]^+ + Br^-$

B = $C_2HCl_3O_2$, Trichloroacetic acid; T = 273.1°K (212)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00632	2.1993	0.0795
.02	.00681	2.1669	.1636
.05	.00703	2.1547	.239
.1	.00731	2.1361	.327
.2	.00752	2.1238	.455

B = $C_2H_2Cl_2O_2$, Dichloroacetic acid; T = 273.1°K (212)

0.02	0.00677	2.1694	0.1636
.05	.00702	2.1537	.239
.1	.00723	2.1409	.327
.2	.00740	2.1308	.455

B = $C_2H_3ClO_2$, Chloroacetic acid; T = 273.1°K (212)

0.02	0.00656	2.1831	0.1627
.05	.00673	2.1720	.138
.1	.00677	2.1694	.327
.2	.00685	2.1643	.455

B = $C_2H_4O_2$, Acetic acid; T = 273.1°K (212)

0.02	0.00638	2.1952	0.1625
.05	.00642	2.1925	.2375
.1	.00641	2.1934	.326
.2	.00636	2.1965	.454

B = KBr; T = 273.1°K (202)

0.0	0.00635	2.1973	0.0797
.02	.00212	2.1644	.1486
.05	.00107	2.0913	.226
.1	.000635	2.0973	.316

B = $KCHO_2$, Formate; T = 273.1°K (212)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.02	0.00678	2.1688	0.1635
.05	..00720	2.1437	.2390
.1	.00752	2.1238	.328
.2	.00805	2.0966	.456

B = $KC_2Cl_3O_2$, Trichloroacetate; T = 273.1°K (212)

0.02	0.00683	2.1656	0.1635
.05	.00719	2.1433	.2390
.1	.00755	2.1221	.328
.2	.00802	2.0968	.456

B = $KC_2HCl_2O_2$, Dichloroacetate; T = 273.1°K (212)

0.02	0.00689	2.1618	0.1640
.05	.00725	2.1397	.2393
.1	.00763	2.1175	.328
.2	.00811	2.0910	.456

B = $KC_2H_2ClO_2$, Chloroacetate; T = 273.1°K (212)

0.02	0.00687	2.1630	0.1640
.05	.00726	2.1391	.1395
.1	.00764	2.1169	.328
.2	.00818	2.0872	.4562

$[CoCl_2(NH_3)_4]IO_3(s) = [CoCl_2(NH_3)_4]^+ + IO_3^-$

B = NaCl; T = 273.1°K (204, 212)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00441	2.3556	0.0670
.02	.00486	2.3134	.1576
.05	.00524	2.2807	.235
.1	.00568	2.2457	.325

B = $NaClO_3$; T = 273.1°K (204, 212)

0.02	0.00491	2.3089	0.1577
.05	.00528	2.2774	.235
.1	.00576	2.2396	.325

B = KCl; T = 273.1°K (204, 212)

0.02	0.00487	2.3125	0.1576
.05	.00525	2.2798	.235
.1	.00571	2.2434	.325

B = $KClO_3$; T = 273.1°K (204, 212)

0.02	0.00491	2.3089	0.1577
.05	.00531	2.2749	.235
.1	.00579	2.2374	.326

$[CoCl_2(NH_3)_4]NO_3(s) = [CoCl_2(NH_3)_4]^+ + NO_3^-$

B = HCl; T = 273.1°K (212)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00383	2.4169	0.0619
.005	.00404	2.3936	.0951
.01	.00410	2.3872	.1187
.05	.00447	2.3497	.233
.1	.00474	2.3242	.3235

B = NaCl; T = 273.1°K (204, 212)

0.0 (204)	0.00386	2.4134	0.01962
.005(212)	.00395	2.4034	.0946
.01 (212)	.00405	2.3925	.1185
.05 (212)	.00449	2.3478	.2334
.05 (204)	.00451	2.3458	.234
.1 (212)	.00480	2.3188	.3234
.1 (204)	.004835	2.3156	.323

B = $NaC_6H_5SO_3$, Benzenesulfonate; T = 273.1°K (212)

0.005	0.00394	2.4045	0.0945
.01	.00404	2.3936	.1183
.05	.00445	2.3516	.2331
.1	.00477	2.3215	.3235
.2	.00519	2.2948	.453

B = KCl; T = 273.1°K (212)

0.005	0.00399	2.3991	0.0948
.01	.00408	2.3893	.1186
.03	.00434	2.3625	.1851
.05	.00458	2.3391	.2337
.1	.00496	2.3045	.324
.1 (204)	.00500	2.3010	.324

B = $KCHO_2$, Formate; T = 273.1°K (212)

0.005	0.00395	2.4035	0.0946
.01	.00409	2.3883	.1186
.05	.00455	2.3420	.2336
.1	.00487	2.3125	.3235
.2	.00533	2.2733	.453
.5	.00635	2.1972	.711
1.0	.00760	2.1192	1.004

$[CoCl(NH_3)_5]Cl_2(s) = [CoCl(NH_3)_5]^{++} + 2Cl^-$

B = NaCl; T = 273.1°K (204)

c_B	s_A	log $(1/c_\pm)$	$\mu^{\frac{1}{2}}$
0.0	0.0091	1.8403	0.1652
.1	.000593	1.7355	.318
B = KOH; T = 273.1°K (212)			
0.02	0.01090	1.7619	0.2295
.05	.01320	1.6787	.309
.1	.01310	1.6820	.373
B = KCl; T = 273.1°K (204, 212)			
0.1	0.000610	1.7381	0.318

$[CoBr(NH_3)_5]Cl_2(s) = [CoBr(NH_3)_5]^{++} + 2Cl^-$

B = NaCl; T = 273.1°K (204)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00542	2.0653	0.1275
.1	.000213	1.8894	.317
B = $NaClO_3$; T = 273.1°K (212)			
0.05	0.00694	1.9579	0.266
.1	.00791	1.9011	.352
1.0	.01511	1.6200	1.205
B = KCl; T = 273.1°K (204)			
0.1	0.000220	1.8844	0.317
B = $KClO_3$; T = 273.1°K (212)			
0.05	0.00699	1.9558	0.264
.1	.00792	1.9006	.352

$[CoCl(NH_3)_5]Br_2(s) = [CoCl(NH_3)_5]^{++} + 2Br^-$

B = $MgSO_4$; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00725	1.9390	0.1475
.01	.00916	1.8374	.259
.02	.01027	1.7877	.333
.05	.01245	1.7041	.487
B = $Ca(CHO_2)_2$, Formate; T = 273.1°K (212)			
0.01	0.00815	1.8881	0.233
.02	.00900	1.8451	.295
.04	.00979	1.8085	.386
.05	.00997	1.8006	.424
B = Na_2SO_4; T = 273.1°K (212)			
0.01	0.00903	1.8436	0.239
.02	.01040	1.7823	.302
.05	.01312	1.6814	.435
B = $KC_2HCl_2O_2$, Dichloroacetate; T = 273.1°K (212)			
0.01	0.00774	1.9106	0.1822
.05	.00938	1.8271	.279
.075	.00980	1.8081	.322
.1	.01016	1.7964	.361
B = $K_2C_8H_4O_4$, Phthalate; T = 273.1°K (212)			
0.01	0.00932	1.8299	0.2405
.02	.01073	1.7697	.304
.05	.01340	1.6722	.436
.1	.01604	1.5968	.590

$[CoBr(NH_3)_5]Br_2(s) = [CoBr(NH_3)_5]^{++} + 2Br^-$

B = $C_2HCl_3O_2$, Trichloroacetic acid; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00275	2.3600	0.0908
.1	.00372	2.2288	.333
.2	.00411	2.1855	.460

B = $NaClO_3$; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.02	0.00323	2.2901	0.1724
.05	.00369	2.2323	.247
.1	.00420	2.1760	.335
B = $NaCHO_2$, Formate; T = 273.1°K (212)			
0.02	0.00315	2.3010	0.1715
.05	.00351	2.2540	.246
.1	.00393	2.2039	.333
.2	.00442	2.1539	.462
.5	.00527	2.0775	.718
1.0	.00593	2.0262	1.008
B = $KClO_3$; T = 273.1°K (212)			
0.02	0.00323	2.2901	0.1724
.05	.00371	2.2299	.247
.1	.00425	2.1709	.335
B = $KCHO_2$, Formate; T = 273.1°K (212)			
0.02	0.00323	2.2901	0.172
.05	.00357	2.2466	.2465
.1	.00397	2.2005	.334
.2	.00455	2.1413	.462
.5	.00549	2.0597	.718
1.0	.00648	1.9877	1.010
B = $KC_2Cl_3O_2$, Trichloroacetate; T = 273.1°K (212)			
0.1	0.00388	2.2105	0.333
.2	.00444	2.1519	.462

$[Co(NO_2)_2(NH_3)_4]Cl(s) = [Co(NO_2)_2(NH_3)_4]^+ + Cl^-$

B = KCl; T = 273.1°K (199, 202)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.02216	1.6544	0.1490
.02	.01515	1.6370	.1875
.05	.01005	1.6097	.2451
.1	.00640	1.5840	.3263
B = $KCHO_2$, Formate; T = 273.1°K (212)			
0.0	0.0222	1.6536	0.1490
.02	.02310	1.6364	.2075
.05	.02400	1.6198	.270
.1	.02520	1.5986	.354

$[Co(NO_2)_2(NH_3)_4]ClO_4(s) = [Co(NO_2)_2(NH_3)_4]^+ + ClO_4^-$

B = $C_2HCl_3O_2$, Trichloroacetic acid; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.01239	1.9069	0.1114
.1	.01398	1.8545	.3372
B = $NaCHO_2$, Formate; T = 273.1°K (212)			
0.05	0.01362	1.8658	0.252
.1	.01420	1.8477	.3375
B = $KCHO_2$, Formate; T = 273.1°K (212)			
0.05	0.01423	1.8468	0.2532
.1	.01566	1.8052	.340
B = $KC_2Cl_3O_2$, Trichloroacetate; T = 273.1°K (212)			
0.1	0.01562	1.8063	0.340

$\alpha[Co(NO_2)_2(NH_3)_4]NO_3(s) = \alpha[Co(NO_2)_2(NH_3)_4]^+ + NO_3^-$

B = HNO_3; T = 273.1°K (200)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00546	2.2628	0.0739
.02	.001610	2.2293	.147
.05	.000793	2.1974	.225
.1	.000481	2.1578	.323

B = $C_2HCl_3O_2$, Trichloroacetic acid; T = 293.1°K (200)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.01483	1.8289	0.1216
.2	.01749	1.7572	.466
.387	.01811	1.7421	.636

B = $Pb(NO_3)_2$; T = 293.1°K (200)

0.05	0.00346	1.7230	0.391

B = $NaNO_3$; T = 293.1°K (200)

0.05	0.00497	1.7867	0.234
.1	.00307	1.7498	.321
.2	.001935	1.6541	.449

B = $Na_2C_2O_4$, Oxalate; T = 273.1°K (200)

0.02	0.00629	2.2013	0.2572
.05	.00683	2.1656	.3956
.1	.00745	2.1278	.552

B = $NaC_6H_5O_3S$, Benzenesulfonate; T = 293.1°K (200)

0.2	0.01897	1.7219	0.4675

B = KOH; T = 273.1°K (200)

0.02	0.00605	2.2182	0.161
.05	.00445	2.3514	.233
.1	.00343	2.4647	.321

B = KNO_3; T = 273.1°K (200)

0.02	0.001654	2.2230	0.147
.05	.000851	2.1819	.225
.1	.000524	2.1393	.3165

B = $KCHO_2$, Formate

T = 273.1°K (200)

0.02	0.00590	2.2291	0.161
.05	.00633	2.1986	.237
.1	.00684	2.1649	.326
.2	.00760	2.1192	.456

T = 293.1°K (200)

0.05	0.01666	1.7783	0.258
.1	.01772	1.7515	.342
.2	.01926	1.7153	.468
.5	.02298	1.6486	.722

B = KCNS; T = 273.1°K (200)

0.02	0.00601	2.2211	0.161
.05	.00657	2.1824	.238
.1	.00730	2.1367	.327

$\beta[Co(NO_2)_2(NH_3)_4]NO_3(s) = \beta[Co(NO_2)_2(NH_3)_4]^+ + NO_3^-$

B = HNO_3; T = 273.1°K (200)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00494	2.3063	0.0702
.02	.001340	2.2718	.146
.05	.000660	2.2379	.225
.1	.000400	2.1981	.316

B = $C_2HCl_3O_2$, Trichloroacetic acid; T = 293.1°K (200, 212)

0.0.	0.01298	1.8867	0.1138
.2	.01545	1.8111	.464
.387	.01601	1.7954	.634

B = $Pb(NO_3)_2$; T = 293.1°K (200)

0.05	0.00274	1.6892	0.3904

B = $NaNO_3$

T = 273.1°K (200)

0.0 (206)	0.00501	2.3002	0.0714
.02	.00138	2.2651	.146
.05	.000706	2.2231	.225

B = $NaNO_3$.—(*Continued*)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.1 (206)	0.000409	2.1854	0.316
.1	.000436	2.1794	.316

T = 278.12°K (206)

0.0	0.00645	2.1904	0.0802
.1	.000666	2.0743	.316

T = 283.16°K (206)

0.0	0.00821	2.0857	0.0904
.1	.00104	1.9795	.317

T = 288.17°K (206)

0.0	0.0104	1.9820	0.102
.1	.001609	1.8643	.317

T = 293.1°K (200, 206)

0.0 (206)	0.01306	1.8841	0.114
.0	.01298	1.8867	.1138
.05	.00390	1.8387	.232
.1	.00243	1.8070	.319
.1 (206)	.00244	1.7589	.318
.2	.001515	1.7626	.448

B = $NaC_6H_5O_3S$, Benzenesulfonate; T = 293.1°K (200)

0.2	0.01672	1.7768	0.465

B = $Na_2C_2O_4$, Oxalate; T = 273.1°K (200)

0.02	0.00572	2.2424	0.256
.05	.00621	2.2069	.395
.1	.00678	2.1688	.552

B = KOH; T = 273.1°K (200, 212)

0.02	0.00553	2.2573	0.1595
.05	.00405	2.3925	.232
.1	.00311	2.5072	.320

B = KNO_3

T = 273.1°K (200)

0.0	0.00501	2.3002	0.0714
.02	.001376	2.2658	.146
.05	.000706	2.2231	.225
.1 (206)	.000441	2.1684	.316
.1	.000436	2.1799	.317

T = 278.12°K (206)

0.1	0.000698	2.0635	0.316

T = 283.16°K (206)

0.1	0.001098	1.9573	0.317

T = 288.17°K (206)

0.1	0.001694	1.8498	0.317

T = 293.1°K (206)

0.1	0.00256	1.7964	0.318

B = $KCHO_2$, Formate

T = 273.1°K (199, 200, 202)

0.02	0.00536	2.2708	0.1593
.05	.00575	2.2403	.236
.1	.00621	2.2069	.3258
.2	.00693	2.1593	.455

T = 293.1°K (199, 200, 202)

0.05	0.01467	1.8336	0.254
.1	.01571	1.8038	.340
.2	.01713	1.7662	.4655
.5	.02035	1.6893	.721

B = KCNS; T = 273.1°K (200, 212)

0.02	0.00546	2.2628	0.1597
.05	.00596	2.2247	.2365
.1	.00663	2.1785	.3265

$[CoCl(NH_3)_5](NO_3)_2(s) = [CoCl(NH_3)_5]^{++} + 2NO_3^-$

B = $NaNO_3$; T = 273.1°K (204)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.1	0.003670	1.4580	0.333

B = KNO_3; T = 273.1°K (204)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.1	0.00397	1.4451	0.334

$[CoNO_2(NH_3)_5](NO_3)_2(s) = [CoNO_2(NH_3)_5]^{++} + 2NO_3^-$

B = $MgCl_2$; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.0170	1.5689	0.226
.01	.0185	1.5321	.292

B = Na_2SO_4; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.01	0.0197	1.5058	0.298
.02	.0221	1.4549	.382
.05	.0272	1.3646	.481
.1	.0336	1.2730	.633

B = KCl; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.01	0.01784	1.5479	0.252
.02	.01858	1.5303	.275

B = $KC_2HCl_2O_2$, Dichloroacetate; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.02	0.0184	1.5345	0.274
.05	.0201	1.4961	.332
.1	.0215	1.3669	.4105

$[Co(NH_3)_6](NO_3)_3(s) = [Co(NH_3)_6]^{+++} + 3NO_3^-$

B = $NaNO_3$; T = 273.1°K (204)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.1	0.00450	1.2954	0.3744

B = KNO_3; T = 273.1°K (204)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.1	0.00493	1.2818	0.364

$[CoCl_2(NH_3)_4]CNS(s) = [CoCl_2(NH_3)_4]^+ + CNS^-$

B = $MgSO_4$; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00289	2.5391	0.0538
.02	.00340	2.4685	.2887
.05	.00358	2.4461	.451
.1	.00379	2.4214	.635
.2	.00400	2.3979	.896

B = NaCl; T = 273.1°K (204, 212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0 (204)	0.00282	2.5498	0.0531
.02	.00313	2.5045	.1520
.05	.00332	2.4789	.231
.1	.00353	2.4522	.322

B = $NaClO_3$; T = 273.1°K (199, 202)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.01	0.00306	2.5143	0.1142
.02 (212)	.00316	2.4003	.152
.03	.00327	2.4855	.1825
.05	.00339	2.4698	.2310
.05 (212)	.00337	2.4724	.231
.1 (204)	.003605	2.4431	.321

B = KCl; T = 273.1°K (204, 212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00282	2.5498	0.0531
.02	.00314	2.5131	.1520
.05	.003355	2.4743	.231
.1	.003580	2.4461	.322
.2	.00389	2.4101	.451

B = $KClO_3$; T = 273.1°K (204, 212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00282	2.5498	0.0531
.02	.00318	2.4976	.1522
.05	.00339	2.4698	.231
.1	.003645	2.4383	.318

B = $KCHO_2$, Formate; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.01	0.00300	2.5229	0.1140
.03	.00321	2.4935	.182
.05	.00331	2.4802	.231
.1	.00345	2.4622	.321
.2	.00374	2.4272	.451
.5	.00409	2.3883	.710
1.0	.00439	2.3576	1.002

$[CoCNS(NH_3)_5](IO_3)_2(s) = [CoCNS(NH_3)_5]^{++} + 2IO_3^-$

B = $NaCHO_2$, Formate; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00204	2.4897	0.0782
.02	.00230	2.4376	.164
.05	.00268	2.3712	.241
.1	.00312	2.3051	.330
.2	.00367	2.2346	.459
.5	.00488	2.1109	.717
1.0	.00635	1.9965	1.010

B = KOH; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.02	0.00286	2.3427	0.169
.05	.00324	2.2888	.244
.1	.00323	2.2901	.331

$[CoNCS(NH_3)_5]SO_4(s) = [CoNCS(NH_3)_5]^{++} + SO_4^{--}$

B = $MgSO_4$; T = 273.1°K (202)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.01177	1.9292	0.217
.02	.01005	1.7599	.3494
.05	.00980	1.6161	.489
.1	.01034	1.4712	.664

$[CoC_2O_4(NH_3)_4]Cl(s) = [CoC_2O_4(NH_3)_4]^+ + Cl^-$

B = NaCl; T = 273.1°K (204)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.1	0.0057	1.6100	0.325

B = KCl; T = 273.1°K (204)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.1	0.00581	1.6056	0.325

$[CoC_2O_4(NH_3)_4]ClO_4(s) = [CoC_2O_4(NH_3)_4]^+ + ClO_4^-$

B = $MgSO_4$; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00510	2.2924	0.0714
.05	.00739	2.1314	.455
.1	.00823	2.0846	.638

B = $C_2HCl_3O_2$, Trichloroacetic acid; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.1	0.00607	2.2168	0.325
.2	.00638	2.1952	.454

B = NaCl; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.05	0.00614	2.2118	0.237
.1	.00684	2.1649	.327

B = $NaCHO_2$, Formate; T = 273.1°K (199, 202, 212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00508	2.2931	0.0713
.05	.005965	2.2244	.2365
.1	.00640	2.1938	.3265
.2	.00718	2.1439	.455

B = KOH; T = 293.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.0140	1.8539	0.1182
.02	.01603	1.7951	.1897
.05	.01814	1.7414	.261
.1	.01808	1.7428	.343

B = KCl; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.05	0.00634	2.1979	0.237
.1	.00712	2.1477	.327

B = KCHO$_2$, Formate; T = 273.1°K (212)

0.05	0.00616	2.2104	0.237
.1	.00679	2.1681	.327
.2	.00796	2.0991	.451

B = KC$_2$Cl$_3$O$_2$, Trichloroacetate; T = 273.1°K (212)

0.1	0.00677	2.1694	0.327
.2	.00781	2.1073	.456

$[CoC_2O_4(NH_3)_4]NO_3(s) = [CoC_2O_4(NH_3)_4]^+ + NO_3^-$

B = NaNO$_3$; T = 273.1°K (204)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.1	0.000777	2.0531	0.317

B = KCl; T = 273.1°K (212)

0.0	0.00658	2.1818	0.0811
.02	.00736	2.1331	.1655
.05	.00803	2.0967	.241
.1	.00905	2.0455	.330

B = KNO$_3$; T = 273.1°K (204)

0.1	0.000816	2.0424	0.317

$[CoCl(NH_3)_5]C_2O_4(s) = [CoCl(NH_3)_5]^{++} + C_2O_4^{--}$

B = MgSO$_4$; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.000359	3.4449	0.0379
.02	.00238	2.6234	.2992
.05	.00354	2.4510	.4630
.1	.00608	2.2161	.650
.2	.01150	1.9393	.920
.5	.02040	1.6904	1.442
1.0	.02930	1.5331	2.025

B = KCl; T = 273.1°K (212)

0.02	0.000359	3.4449	0.1462
.05	.000528	3.2774	.2285
.1	.000715	3.1467	.320
.15	.000935	3.0392	.392

B = KCHO$_2$, Formate; T = 273.1°K (212)

0.1	0.000849	3.0711	0.321
.2	.001113	2.9535	.452
.5	.001715	2.7657	.712
1.0	.002424	2.6155	1.003

$[CoNO_2(NH_3)_5]C_2O_4(s) = [CoNO_2(NH_3)_5]^{++} + C_2O_4^{--}$

B = MgSO$_4$; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.0001614	3.7921	0.0254
.02	.00131	2.8827	.292
.05	.00183	2.7375	.455
.1	.00310	2.5086	.642
.2	.00445	2.3516	.904
1.0	.01026	1.9889	2.010

B = KCl; T = 273.1°K (212)

0.02	0.00028	3.5528	0.145
.05	.000382	3.4179	.227
.1	.000487	3.3125	.319
.2	.000705	3.1518	.450
.5	.001212	2.9165	.710
1.0	.002011	2.6966	1.004

B = KCHO$_2$, Formate; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.02	0.000272	3.5654	0.145
.05	.000356	3.4485	.227
.1	.000455	3.3420	.319
.2	.000612	3.2132	.449
.5	.000967	3.0156	.710
1.0	.001277	2.8938	1.002

$[CoCl_2(NH_3)_4]C_6H_2N_3O_7(s) = [CoCl_2(NH_3)_4]^+ + C_6H_2N_3O_7^-$

B = NaCl; T = 273.1°K (204, 212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.000212	3.6737	0.01456
.02	.000253	3.5969	.1403
.05	.000266	3.5751	.224
.1	.000285	3.5450	.317
.2	.000301	3.5223	.4475
.5	.000338	3.4711	.708
1.0	.000414	3.3930	1.000

B = KCl; T = 273.1°K (204, 212)

0.02	0.000257	3.5800	0.1424
.05	.000274	3.5622	.2247
.1	.000295	3.5302	.317
.2	.000335	3.4750	.4475
.5	.000418	3.3788	.707
1.0	.000536	3.3708	1.000

$Tl[Co(NO_2)_4(NH_3)_2](s) = Tl^+ + [Co(NO_2)_4(NH_3)_2]^-$

B = KClO$_3$; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00259	2.5867	0.0509
.02	.00274	2.5622	.1507
.05	.00287	2.5421	.230
.1	.00298	2.5258	.321

B = KNO$_3$; T = 273.1°K (212)

0.02	0.00278	2.5560	0.1507
.05	.00294	2.5317	.230
.1	.00308	2.5114	.321

B = KHCO$_2$, Formate; T = 273.1°K (212)

0.02	0.00273	2.5638	0.1507
.05	.00285	2.5451	.230
.1	.00287	2.5421	.3204
.15	.00283	2.5482	.391
.2	.00277	2.5575	.450

$[CoCl(NH_3)_5]PtCl_6(s) = [CoCl(NH_3)_5]^{++} + PtCl_6^{--}$

B = MgSO$_4$; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.000091	4.0410	0.01907
.05	.000282	3.5497	.448
.1	.000483	3.3161	.642

B = KCl; T = 273.1°K (212)

0.0	0.000092	4.0362	0.01919
.02	.000132	3.8794	.143
.1	.000268	3.5719	.318
.15	.000327	3.4855	.389

$[Co(NH_3)_6][Fe(CN)_6](s) = [Co(NH_3)_6]^{+++} + [Fe(CN)_6]^{---}$

B = MgSO$_4$; T = 298.1°K (814)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00002925	4.5539	0.0162
.001	.00006506	4.1867	.0677
.005	.0001524	3.8170	.1462
.01	.0002267	3.6445	.2050

$[Co(NH_3)_6][Fe(CN)_6]$.—(*Continued*)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
B = $BaCl_2$; T = 298.1°K (^{814})			
0.005	0.00008314	4.0802	0.1255
B = NaCl			
T = 273.1°K (^{212})			
0.0	0.0000098	5.0088	0.00939
.1	.0000831	4.0804	.317
1.0	.000791	3.1018	1.002
T = 298.1°K (^{814})			
0.0005	0.00003379	4.4712	0.0284
.001	.00003526	4.4527	.0363
.005	.0000464	4.3335	.0736
.01	.0000624	4.1925	.1028
B = KCl; T = 273.1°K (^{956}) *from* (^{212})			
0.05	0.0000534	4.2725	0.224
.1	.0000911	4.0405	.317
.2	.0001724	3.7645	.449
.5	.000462	3.3354	.710
.75	.000751	3.1244	.870
1.0	.001079	2.9670	1.003
2.0	.00272	2.5654	1.423
B = KNO_3; T = 298.1°K (^{814}); *cf.* (^{956})			
0.0005	0.0000320	4.4948	0.0281
.001	.0000367	4.4353	.0365
.003	.0000427	4.3690	.0582
.005	.0000536	4.2708	.0740
.01	.0000660	4.1805	.1029
.02	.0000880	4.0516	.1442
.03	.0001173	3.9303	.1762
.05	.0001577	3.8022	.2268
.06	.0001799	3.7450	.2482
.07	.0002098	3.6782	.2681
.1	.0002887	3.5496	.3203
B = K_2SO_4; T = 298.1°K (^{814})			
0.001	0.00006224	4.2059	0.0597

$[Co(NO_2)_2(NH_3)_4][Co(NO_2)_4(NH_3)_2](s) = [Co(NO_2)_2(NH_3)_4]^+ + [Co(NO_2)_4(NH_3)_2]^-$

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
B = NaCl; T = 293.1°K ($^{205,\ 209}$)			
0.0	0.00037	3.4318	0.01924
.001	.00138	2.8601	.0488
.002	.00238	2.6234	.0662
B = KCl			
T = 273.1°K (^{212})			
0.0	0.000096	4.0177	0.0098
.05	.000124	3.9066	.224
.1	.000132	3.8794	.316
.2	.000149	3.8268	.447
.5	.000202	3.6946	.707
T = 293.1°K ($^{205,\ 209}$)			
0.001	0.00138	2.8601	0.0488
.002	.00238	2.6234	.0662
B = KNO_3; T = 293.1°K ($^{205,\ 209}$)			
0.001	0.00138	2.8601	0.0488
.002	.00238	2.6234	.0662
B = $KCHO_2$, Formate; T = 273.1°K (^{212})			
0.05	0.000119	3.9245	0.224
.1	.000128	3.8928	.316
.2	.000139	3.8570	.447
.5	.000175	3.7570	.707

$[Co(NO_2)_2(NH_3)_4]_2SO_4(s) = 2[Co(NO_2)_2(NH_3)_4]^+ + SO_4^{--}$

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
B = $MgCl_2$; T = 273.1°K (^{212})			
0.0	0.00096	2.8170	0.0536
.01	.001326	2.6768	.184
.02	.001500	2.6232	.254
.05	.001855	2.5315	.394
.1	.002235	2.4500	.554
B = $Na_2C_2O_4$, Oxalate; T = 273.1°K (^{212})			
0.01	0.001222	2.7122	0.1835
.025	.001407	2.6510	.284
.05	.00161	2.5924	.393
.1	.001891	2.5226	.552
B = KCl; T = 273.1°K (^{212})			
0.01	0.001115	2.7516	0.1155
.02	.001199	2.7205	.1536
.05	.001385	2.6578	.232
.1	.001612	2.5919	.324
B = $KC_2HCl_2O_2$, Dichloroacetate; T = 273.1°K (^{212})			
0.02	0.001189	2.7241	0.1535
.05	.001366	2.6638	.2327
.1	.001558	2.6067	.323

$[CoC_2O_4(NH_3)_4][Co(NO_2)_4(NH_3)_2] = [CoC_2O_4(NH_3)_4]^+ + [Co(NO_2)_4(NH_3)_2]^-$

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
B = NaCl			
T = 273.1°K (^{212})			
0.0	0.00103	2.9872	0.0321
.02	.001145	2.9412	.1452
.05	.00123	2.9101	.2265
.1	.00137	2.8633	.318
T = 293.1°K (^{212})			
0.0	0.002659	2.4753	0.0515
.1	.003531	2.4521	.321
B = $NaNO_3$; T = 293.1°K (^{204})			
0.1	0.003615	2.4419	0.3215
B = $NaCHO_2$, Formate; T = 273.1°K (^{212})			
0.02	0.00111	2.9547	0.1453
.05	.00120	2.9208	.226
.1	.00128	2.8928	.318
B = KCl			
T = 273.1°K (^{212})			
0.02	0.00115	2.9397	0.1454
.05	.00123	2.9101	.226
.1	.00137	2.8633	.3185
T = 293.1°K (^{204})			
0.1	0.003647	2.438	0.3215
B = KNO_3			
T = 273.1°K (^{212})			
0.02	0.00116	2.9355	0.1455
.05	.00126	2.8996	.2262
.1	.00141	2.8508	.318
T = 293.1°K (^{204})			
0.1	0.003723	2.4291	0.3215
B = $KCHO_2$, Formate; T = 273.1°K (^{212})			
0.02	0.00112	2.9508	0.1452
.05	.00121	2.9172	.2263
.1	.00132	2.8796	.318

$[Co(CNS)(NO_2)(NH_3)_4][Co(NO_2)_2C_2O_4(NH_3)_2](s) = [Co(CNS)(NO_2)(NH_3)_4]^+ + [Co(NO_2)_2C_2O_4(NH_3)_2]^-$

B = $NaCl$

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
T = 288.1°K (209)			
0.0	0.0003355	3.4743	0.01831
.0003	.0003377	3.4715	.0252
.001	.0003405	3.4679	.0366
.002	.0003451	3.4621	.0484
.01	.0003627	3.4405	.1015
.02	.0003790	3.4214	.1428
T = 293.1°K (207, 1479)			
0.0	0.0004449	3.3478	0.0212
.005	.000476	3.3224	.0740
.01	.0004894	3.3103	.1024
.02	.0005051	3.2964	.143
.05	.000540	3.2674	.225
.10	.000571	3.2434	.317

B = Na_2SO_4; T = 293.1°K (207, 1479)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0025	0.000481	3.3179	0.0892
.005	.000499	3.3019	.1245
.01	.0005137	3.2893	.1744
.025	.000552	3.2581	.275
.05	.000587	3.2314	.3875

B = KNO_3; T = 288.1°K (209)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.001	0.0003418	3.4662	0.0366
.0025	.0003488	3.4574	.0538
.005	.0003572	3.4471	.0732
.01	.0003669	3.4345	.1015

B = $K_3Co(CN)_6$; T = 288.1°K (209)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.00033	0.0003464	3.4604	0.0484
.00067	.0003556	3.4490	.0660
.00167	.0003687	3.4333	.1015

$[CoC_2O_4(NH_3)_4][Co(NO_2)_2C_2O_4(NH_3)_2](s) = [CoC_2O_4(NH_3)_4]^+ + [Co(NO_2)_2C_2O_4(NH_3)_2]^-$

B = $MgSO_4$; T = 288.1°K (209)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00049	3.3098	0.0221
.0005	.0005102	3.2923	.0501
.001	.000522	3.2823	.0672
.0025	.0005446	3.2639	.1027
.005	.0005710	3.2434	.1435

B = $BaCl_2$; T = 288.1°K (209)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0005	0.0005059	3.2959	0.0447
.0015	.0005222	3.2822	.0709
.0025	.0005375	3.2696	.0826
.005	.0005649	3.2480	.1245
.01	.0006093	3.2152	.1750

B = $NaCl$; T = 288.1°K (209)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0003	0.0004935	3.3067	0.0282
.0007	.0004977	3.3030	.0346
.001	.0005	3.3010	.0387
.002	.0005067	3.2952	.0500
.005	.000522	3.2823	.0743
.008	.0005326	3.2736	.0924
.01	.0005396	3.2679	.1027
.02	.0005646	3.2483	.1434
T = 293.1°K (207, 1479)			
0.0	0.000670	3.1739	0.0259
.005	.0007136	3.1469	.0756
.01	.000739	3.1314	.1036
.02	.0007725	3.1121	.1441
0.05	0.0008482	3.0715	0.2255
.1	.0009400	3.0269	.3177
.2	.0010800	2.9666	.449
.5	.00144	2.8416	.708
1	.002050	2.6882	1.01

B = Na_2SO_4; T = 293.1°K (207, 1479)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0025	0.0007417	3.1298	0.0906
.005	.0007879	3.1035	.1255
.01	.0008496	3.0708	.1752
.025	.0009775	3.0099	.275
.05	.001131	2.9465	.3885
.1	.00134	2.8729	.548
.25	.00178	2.7496	.868
.5	.00231	2.6364	1.226

B = KNO_3; T = 288.1°K (209)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.001	0.0005	3.3010	0.0387
.0025	.0005088	3.2935	.0549
.005	.0005218	3.2825	.0743
.01	.0005414	3.2665	.1027
.02	.0005725	3.2422	.1434

B = $K_3Co(CN)_6$; T = 288.1°K (209)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0001667	0.0005055	3.2963	0.0388
.0003334	.000515	3.2882	.0502
.0006667	.0005289	3.2764	.0673
.0016667	.0005572	3.2640	.1028

$[CoC_2O_4(NH_3)_4]_2S_2O_8(s) = 2[CoC_2O_4(NH_3)_4]^+ + S_2O_8^{--}$

B = $NaCl$; T = 293.1°K (207, 1479)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.000755	2.9214	0.04755
.01	.0008735	2.8580	.112
.02	.0009438	2.8244	.151
.05	.001091	2.7615	.231
.1	.0012956	2.6867	.3210

B = Na_2SO_4; T = 293.1°K (207, 1479)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.005	0.0009505	2.8213	0.1335
.01	.001064	2.7724	.182
.025	.001316	2.6800	.280
.05	.001642	2.5839	.393

$[CoC_2O_4(NH_3)_4]_2S_2O_6(s) = 2[CoC_2O_4(NH_3)_4]^{++} + S_2O_6^{--}$

B = $MgSO_4$; T = 288.1°K (209)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.0001545	3.6104	0.0215
.0005	.0001652	3.5813	.0500
.001	.0001723	3.5630	.0672
.0025	.0001866	3.5284	.1028

B = $BaCl_2$; T = 288.1°K (209)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0005	0.0001641	3.5842	0.0446
.001	.0001710	3.5663	.0593
.0025	.0001862	3.5293	.0898
.005	.0002032	3.4914	.1249

B = K_2SO_4; T = 288.1°K (209)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0003	0.0001614	3.5914	0.0372
.0005	.0001630	3.5871	.0446
.0005	.000165	3.5818	.0447
.001	.0001718	3.5643	.0593
.0015	.0001775	3.5501	.0709
.0025	.0001878	3.5256	.0897

$[CoC_2O_4(NH_3)_4]_2S_2O_6$.—(*Continued*)

B = $K_3Co(CN)_6$; T = 288.1°K (209)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.00033	0.0001651	3.5816	0.0500
.00067	.0001728	3.5618	.0673
.00167	.0001889	3.5231	.1028

B = NaCl; T = 288.1°K (209)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.001	0.0001597	3.5960	0.0385
.002	.0001645	3.5831	.0500
.005	.0001737	3.5595	.0744
T = 293.1°K (207)			
0.0	0.000201	3.4961	0.0245
.01	.0002382	3.4224	.1035
.02	.0002601	3.3842	.144
.05	.0003675	3.3115	.2253
.1	.0003638	3.2484	.3175

B = Na_2SO_4; T = 293.1°K (207, 1479)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.005	0.0002597	3.3848	0.1255
.01	.0002945	3.3302	.176
.025	.0003719	3.2389	.276
1.05	.0004563	3.1400	.389

B = KNO_3; T = 288.1°K (209)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.001	0.0001603	3.5744	0.0385
.005	.0001737	3.5595	.0744
.01	.0001880	3.5251	.1028

$[Co(NO_2)_2(NH_3)_4][Co(C_2O_4)_2(NH_3)_3](s) = [Co(NO_2)_2(NH_3)_4]^+ + [Co(C_2O_4)_2(NH_3)_3]^-$

B = KCl; T = 273.1°K (212)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.000593	3.2269	0.0244
.02	.000703	3.1530	.1438
.05	.000790	3.1024	.225
.1	.000917	3.0376	.3274
1.0	.00334	2.4763	1.001

B = $KCHO_2$, Formate; T = 273.1°K (212)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.1	0.000895	3.0482	0.316
1.0	.00233	2.6326	1.000

$[Co(NH_3)_6][Co(C_2O_4)_3](s) = [Co(NH_3)_6]^{+++} + [Co(C_2O_4)_3]^{---}$

B = NaCl; T = 273.1°K (212)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.000019	4.7212	0.01307
.05	.0001014	3.9940	.2255
.1	.000178	3.7496	.317
.2	.000348	3.4584	.447
.5	.001008	2.9966	.713
1.0	.00245	2.6108	1.010

$[Co(NH_3)_6][Co(CN)_6](s) = [Co(NH_3)_6]^{+++} + [Co(CN)_6]^{---}$

B = $MgSO_4$; T = 273.1°K (212)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.000007	5.3548	0.00792
.05	.000243	3.6154	.449
.1	.000390	3.4089	.635
1.0	.00277	2.5574	2.010

B = NaCl; T = 273.1°K (212)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.05	0.0000378	4.4225	0.224
.1	.0000602	4.2204	.316
.1	.0000651	4.1864	.316
.2	.0001246	3.9045	.448

B = NaCl.—(*Continued*)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.5	0.0003472	3.4694	0.709
1.0	.000602	3.2204	1.004

c_B	Range, 10^5 s_A	$\log (1/c_\pm)$		$\mu_c^{\frac{1}{2}}$
T = 293.1°K (208)				
0.0	1.375	4.862	4.862	0.0111
.001	1.69 –1.73	4.772	4.762	.0340
.003	2.11	4.676	4.676	.0565
.005	2.42 –2.49	4.616	4.604	.0723
.010	3.02 –3.22	4.520	4.492	.1002
.015	4.02 –3.83	4.396	4.417	.1239
.020	4.41 –4.70	4.356	4.328	.1428

B = $NaCHO_2$, Formate; T = 273.1°K (212)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.2	0.0001216	3.9151	0.448
.5	.0002632	3.5797	.708
1.0	.0004882	3.3114	1.002

B = KCl; T = 273.1°K (212)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.05	0.0000379	4.4214	0.2245
.1	.0000650	4.1871	.317
.2	.0001246	3.9045	.448
.5	.000347	3.4597	.710
.75	.000562	3.2503	.868
1.0	.000813	3.0899	1.002
2.0	.00207	2.6840	1.420

B = $KCHO_2$, Formate; T = 273.1°K (212)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.2	0.0001377	3.8611	0.448
.5	.0003402	3.4683	.709
1.0	.0007135	3.1466	1.003

$[CoNO_2(NH_3)_5][Co(NO_2)_4(NH_3)_2]_2(s) = [CoNO_2(NH_3)_5]^{++} + 2[Co(NO_2)_4(NH_3)_2]^-$

B = NaCl (204)

T, °K	c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
273.1	0.0	0.000311	3.3065	0.305
273.1	.2	.000621	3.0062	.4485
293.1	.0	.000992	2.8028	.5445
293.1	.2	.001823	2.5385	.453

B = $NaCHO_2$, Formate (204)

T, °K	c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
273.1	0.2	0.000570	3.0434	0.448
293.1	0.2	0.001692	2.5707	0.452

B = KCl (204)

T, °K	c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
273.1	0.2	0.000682	2.9655	0.449
293.1	0.2	0.001952	2.5088	0.453

B = $KCHO_2$ (204)

T, °K	c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
273.1	0.2	0.000629	3.0006	0.448
293.1	0.2	0.001824	2.5383	0.452

$[CoCl(NH_3)_5][Co(NO_2)_4(NH_3)_2]_2(s) = [CoCl(NH_3)_5]^{++} + 2[Co(NO_2)_4(NH_3)_2]^-$

B = NaCl (204)

T, °K	c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
273.1	0.0	0.000173	3.5613	0.02403
273.1	.2	.000353	3.2515	.448
293.1	.0	.000637	2.9952	.0437
293.1	.2	.001187	2.7248	.451

B = $NaCHO_2$ (204)

T, °K	c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
273.1	0.2	0.000325	3.2874	0.447
293.1	0.2	0.001100	2.7579	0.450

B = **KCl** (204)

T, °K	c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
273.1	0.2	0.000393	3.2049	0.448
293.1	0.2	0.001291	2.6884	0.451

B = **$KCHO_2$**, Formate (204)

273.1	0.2	0.000363	3.2394	0.448
.293.1	0.2	0.001207	2.6176	0.450

$[CoCl_2(NH_3)_4]_3[Fe(CN)_6](s) = 3[CoCl_2(NH_3)_4]^+ + [Fe(CN)_6]^{---}$

B = **$MgCl_2$**; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.000121	3.5594	0.02695
.005	.000157	3.4463	.1262
.01	.000171	3.4092	.176
.05	.000231	3.2786	.489
.1	.000261	3.2256	.549

B = **$MgSO_4$**; T = 273.1°K (212)

0.005	0.000149	3.4690	0.1445
.01	.000167	3.4155	.2025
.05	.000222	3.2958	.448
.1	.000251	3.2425	.634

B = **$Ca(CHO_2)_2$**, Formate; T = 273.1°K (212)

0.01	0.000168	3.4169	0.176
.05	.00023	3.2805	.389
.1	.000263	3.2222	.549

B = **Na_2SO_4**; T = 273.1°K (212, 956)

0.005	0.000138	3.5023	0.1256
.01	.000158	3.4435	.176
.05	.000222	3.2958	.389
.1	.000265	3.2190	.549

B = **KCl**; T = 273.1°K (212)

0.01	0.000139	3.5092	0.104
.05	.000193	3.3466	.226
.1	.000233	3.2748	.318

B = **$K_2C_8H_4O_4$**, Phthalate; T = 273.1°K (212)

0.005	0.000144	3.4838	0.1260
.01	.00016	3.4381	.176
.05	.000227	3.2862	.388
.1	.000282	3.1920	.550

$[Co(NH_3)_6][Co(NO_2)_4(NH_3)_2]_3(s) = [Co(NH_3)_6]^{+++} + 3[Co(NO_2)_4(NH_3)_2]^-$

B = **$MgCl_2$**; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.000043	4.0087	0.0161
.01	.0000636	3.8387	.1735
.05	.0000941	3.6686	.388
.1	.0001140	3.5853	.548

B = **$MgSO_4$**; T = 273.1°K (212)

0.01	0.000948	3.6654	0.2015
.05	.00144	3.4836	.447
.1	.00173	3.4042	.634

T = 298.1°K (815)

0.0	0.0001651	3.4245	0.03147
.001	.0002218	3.2962	.07301
.005	.0003083	3.1532	.1478
.01	.0003556	3.0912	.2052
.05	.0005446	2.9061	.4508

B = **$Ca(CHO_2)_2$**, Formate; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.01	0.0000605	3.8604	0.1734
.05	.0000893	3.6913	.388
.1	.0001020	3.6336	.548

B = **$BaCl_2$**; T = 298.1°K (815)

0.001	0.0001822	3.3817	0.06397
.003	.0002048	3.3409	.1011
.01	.0002507	3.2430	.1774
.02	.0002893	3.1809	.2484
.03	.0003211	3.1356	.3032
.05	.0003714	3.0724	.3901
.1	.0004653	2.9745	.5503

B = **$NaNO_3$**; T = 298.1°K (815)

0.001	0.0001724	3.4057	0.04509
.005	.0001946	3.3531	.07853

B = **Na_2SO_4**; T = 273.1°K (212)

0.01	0.000101	3.6379	0.175
.05	.000156	3.4491	.389

B = **KCl**; T = 273.1°K (212)

0.01	0.0000523	3.9237	0.1015
.05	.0000756	3.7637	.2245
.1	.0000960	3.6599	.317

B = **KNO_3**; T = 298.1°K (956)

0.001	0.0001719	3.4069	0.04506
.005	.0001976	3.3446	.07864
.05	.0003040	3.1593	.2277
.1	.0003737	3.0697	.3197

B = **K_2SO_4**; T = 298.1°K (815)

0.001	0.0002302	3.2801	0.06618
.005	.0003271	3.1275	.1302
.01	.0003922	3.0487	.1798
.05	.0006403	2.8358	.3922
.1	.0008320	2.7221	.5522

B = **$K_2C_8H_4O_4$**, Phthalate; T = 273.1°K (212)

0.01	0.000110	3.6008	0.175
.05	.000182	3.3821	.389

$[Co(NH_3)_6][Co(NO_2)_2C_2O_4(NH_3)_2]_3(s) = [Co(NH_3)_6]^{+++} + 3[Co(NO_2)_2C_2O_4(NH_3)_2]^-$

B = **$MgSO_4$**; T = 298.1°K (815)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00008269	3.7247	0.0227
.0002	.0000941	3.6686	.03693
.0005	.000103	3.6294	.05116
.001	.0001144	3.5838	.06845
.003	.0001436	3.4853	.1134
.004	.0001508	3.4638	.1300
.005	.0001600	3.4381	.1447
.007	.0001715	3.4080	.1704
.02	.0002228	3.2943	.2852
.03	.0002439	3.2550	.3484
.04	.0002666	3.2163	.4020
.05	.0002848	3.1877	.4492
.07	.0003238	3.1419	.5308

$[Co(NH_3)_6][Co(NO_2)_2C_2O_4(NH_3)_2]_3$.—(*Continued*)

B = **$BaCl_2$**; T = 298.1°K (815)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0005	0.00008958	3.6900	0.04513
.001	.00009415	3.6684	.05968
.003	.0001067	3.6140	.09818
.005	.0001165	3.5859	.1252
.01	.0001362	3.5080	.1755
.02	.0001645	3.4260	.2469
.04	.0002109	3.3181	.3480
.05	.0002344	3.2722	.3890
.06	.0002605	3.2264	.4260

B = **KNO_3**

T = 288.1°K (209)

0.0	0.00005041	3.9397	0.0174
.001	.00005389	3.9107	.0364
.002	.00005661	3.8893	.0483

T = 298.1°K (815)

0.001	0.00008767	3.6993	0.0390
.003	.00009481	3.6653	.0597
.005	.00010101	3.6379	.0749
.01	.00010984	3.6016	.1032
.02	.00012536	3.5439	.1440
.05	.00015796	3.4435	.2257
.1	.00019992	3.3514	.3180

B = **K_2SO_4**; T = 298.1°K (815)

0.0005	0.0001036	3.6268	0.04604
.001	.00011701	3.5740	.06083
.003	.0001484	3.4708	.09945
.005	.0001676	3.4179	.1264
.007	.00018277	3.3802	.1486
.01	.00020339	3.3338	.1767
.02	.0002512	3.2422	.2479
.03	.00028031	3.1946	.3028
.05	.00033625	3.1155	.3898
.07	.00038090	3.0615	.4605
.1	.00043700	3.0017	.5500

B = **$K_3Fe(CN)_6$**; T = 298.1°K (815)

0.001	0.0001290	3.5316	0.0823
.003	.0002121	3.3157	.1388

B = **$K_4Fe(CN)_6$**; T = 298.1°K (815)

0.0005	0.0001793	3.3886	0.07795

$PbCrO_4(s) = Pb^{++} + CrO_4^{--}$

B = **HCl**; T = 291.1°K (71)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.1	0.000186	3.7305	0.3175
.2	.000393	3.4056	.4490
.3	.000654	3.1844	.5551
.4	.00107	2.9706	6358
.5	.00156	2.8069	.7115
.6	.00225	2.6472	.7804

B = **HNO_3**; T = 291.1°K (71)

0.0	0.0_73	7.523	0.0001
.1	.000129	3.8894	.3170
.2	.000227	3.6439	.4482
.3	.000312	3.5959	.5479
.4	.000401	3.3969	.6337
.5	.000498	3.3028	.7085
.6	.000598	3.2233	.7761

$[CoNO_2(NH_3)_5]CrO_4(s) = [CoNO_2(NH_3)_5]^{++} + CrO_4^{--}$

B = **$MgSO_4$**; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0*	0.000258	3.5884	0.0320
.02*	.00062	3.2076	.287
.05*	.000908	3.0419	.451
.1*	.001237	2.9073	.636
.2	.001804	2.7438	.898
1.0	.00512	2.2907	2.005

* *See also* (199, 202).

B = **NaCl**; T = 273.1°K (203, 212)

0.05 (212)	0.000415	3.3820	0.227
.05 (203)	.000414	3.3830	.227
.1 (212)	.000565	3.2479	.320
.1 (203)	.000563	3.2495	.319
.2 (212)	.000785	3.1051	.450
.2 (203)	.000781	3.1077	.450
.5 (203)	.001054	2.8229	.708

B = **$NaClO_3$**; T = 273.1°K (212)

0.02	0.000318	3.4976	0.145
.05	.000417	3.3799	.227
.1	.000561	3.2510	.320

B = **$NaNO_3$**; T = 273.1°K (212)

0.02	0.000344	3.4634	0.145
.05	.000442	3.3546	.227
.1	.000577	3.2388	.320

B = **$NaCHO_2$**, Formate; T = 273.1°K (212)

0.02	0.000323	3.4908	0.145
.05	.00041	3.3872	.227
.1	.000558	3.2534	.320
.2	.000746	3.1273	.450
.5	.001131	2.9465	.710
1.0	.001729	2.7622	1.003

B = **KCl**; T = 273.1°K (212)

0.02	0.000371	3.4306	0.1465
.05	.00052	3.2840	.228
.1	.00069	3.1612	.321
.2	.000887	3.0521	.450

B = **$KClO_3$**; T = 273.1°K (212)

0.02	0.000332	3.4789	0.145
.05	.000421	3.3757	.227
.1	.000570	3.2441	.320

B = **KNO_3**; T = 273.1°K (212)

0.02	0.000345	3.4622	0.145
.05	.000444	3.3526	.227
.1	.000588	3.2306	.320

B = **$KCHO_2$**, Formate; T = 273.1°K (212)

0.02	0.000361	3.4425	0.1462
.05	.000480	3.3188	.224
.1	.000636	3.1965	.320
.2	.000816	3.0887	.450
.5	.001212	2.9161	.710
1.0	.001787	2.7479	1.003

$[CoNCS(NH_3)_5]CrO_4(s) = [CoNCS(NH_3)_5]^{++} + CrO_4^{--}$

B = **$MgSO_4$**; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.001074	2.9690	0.0655
.02	.00224	2.6498	.297
.05	.00329	2.4828	.4615
.1	.00455	2.4908	.647
.2	.00673	2.1720	.909

B = $MgSO_4$.—(*Continued*)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.5	0.01150	1.9393	1.430
1.0	.01770	1.7520	2.020

B = $NaCHO_2$, Formate; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00107	2.9706	0.0654
.02	.001377	2.8611	.1594
.05	.001570	2.8141	.237
.1	.001835	2.7364	.327

B = $KCHO_2$, Formate; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00107	2.9706	0.0654
.02	.001402	2.8533	.160
.05	.001628	2.7883	.238
.1	.001898	2.7217	.3275

$[Co(NO_2)_2(NH_3)_4][Cr(CNS)_4(NH_3)_2](s) = [Co(NO_2)_2(NH_3)_4]^+ + [Cr(CNS)_4(NH_3)_2]^-$

B = NaCl; T = 293.1°K (205, 209)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0 (205)	0.000143	3.8447	0.01196
.001 (205)	.000115	3.9393	.0334
.001 (209)	.000146	3.8356	.0339

B = KCl; T = 293.1°K (205, 209)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.001	0.000115	3.9393	0.0334
.001	.000146	3.8356	.0339

B = KNO_3; T = 293.1°K (205, 209)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.001	0.000115	3.9393	0.0334
.001	.000146	3.8356	.0339

$[CoC_2O_4(NH_3)_4][Cr(CNS)_4(NH_3)_2](s) = [CoC_2O_4(NH_3)_4]^+ + [Cr(CNS)_4(NH_3)_2]^-$

B = NaCl; T = 293.1°K (204, 205, 207, 209, 1479)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0 (204)	0.001366	2.8645	0.0370
0.0 (205)	.00137	2.8633	.0370
0.0 (1479)	.00139	2.8570	.0373
.001 (205)	.00239	2.6214	.0582
.002 (205)	.00340	2.4685	.0735
.005 (1479)	.001446	2.8398	.0803
.01 (1479)	.001489	2.8271	.1072
.02 (1479)	.001554	2.8085	.1468
.05 (1479)	.001644	2.7841	.2272
.1 (204)	.001737	2.7602	.318
.1 (1479)	.00175	2.7570	.3190
.2 (1479)	.001900	2.7212	.449
.5 (1479)	.00212	2.6737	.709
1 (1479)	.00226	2.6459	1.01

B = Na_2SO_4; T = 293.1°K (1479); *cf.* (207)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0025	0.00151	2.8210	0.0949
.005	.00159	2.7986	.1287
.01	.00171	2.7670	.1780
.025	.001903	2.7206	.277
.05	.002123	2.6730	.390
.1	.002669	2.5737	.554
.25	.002720	2.5654	.870
.5	.002770	2.5575	1.228

B = $NaNO_3$; T = 293.1°K (204)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.1	0.001786	2.7481	0.318

B = KCl; T = 293.1°K (204, 205, 209)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.001	0.00239	2.6214	0.0580
.002	.00340	2.4685	.0735
.1 (204)	.001771	2.7518	.318

B = KNO_3; T = 293.1°K (204, 205, 209)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.001	0.00239	2.6214	0.0582
.002	.00340	2.4685	.0735
.1 (204)	.001813	2.7416	.4185

$[CoC_2O_4(NH_3)_4]_3[Cr(CNS)_6](s) = 3[CoC_2O_4(NH_3)_4]^+ + [Cr(CNS)_6]^{---}$

B = $MgCl_2$; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.000532	2.9163	0.0565
.001	.000577	2.8810	.0804
.005	.000666	2.8187	.1377
.01	.000728	2.7801	.1852
.05	.000954	2.6626	.395

B = $MgSO_4$; T = 273.1°K (212, 956)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.001	0.000586	2.8743	0.0867
.005	.000687	2.8052	.155
.01	.000766	2.7580	.211
.05	.001100	2.6008	.455

B = $Ca(CHO_2)_2$, Formate; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.001	0.000575	2.8825	0.0803
.005	.000665	2.8194	.1377
.01	.000729	2.7795	.1853
.05	.000954	2.6626	.395

B = NaCl; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.001	0.000549	2.9026	0.0654
.005	.000586	2.8743	.0922
.01	.000627	2.8449	.1172
.05	.000797	2.7407	.234

B = Na_2SO_4; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.001	0.000575	2.8825	0.0803
.005	.000678	2.8110	.138
.01	.000770	2.7557	.186
.05	.001177	2.5734	.396

$[CoCl(NH_3)_5][Cr(CNS)_4(NH_3)_2]_2(s) = [CoCl(NH_3)_5]^{++} + 2[Cr(CNS)_4(NH_3)_2]^-$

B = NaCl (204)

T, °K	c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
273.1	0.2	0.000524	3.0800	0.448
293.1	0.2	0.001627	2.5879	0.452

B = $NaCHO_2$, Formate (204)

T, °K	c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
273.1	0.2	0.000477	3.1208	0.448
293.1	0.2	0.001516	2.6286	0.452

B = KCl (204)

T, °K	c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
273.1	0.2	0.000548	3.0605	0.448
293.1	0.2	0.001702	2.5683	0.4525

B = $KCHO_2$, Formate (204)

T, °K	c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
273.1	0.2	0.000510	3.0917	0.448
293.1	0.2	0.001592	2.6074	0.448

$[CoNO_2(NH_3)_5][Cr(CNS)_4(NH_3)_2]_2(s) = [CoNO_2(NH_3)_5]^{++} + 2[Cr(CNS)_4(NH_3)_2]^-$

B = NaCl (204)

T, °K	c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
273.1	0.0	0.000392	3.2060	0.0342
273.1	.2	.000680	2.9668	.449
293.1	.0	.001284	2.6907	.0620
293.1	.2	.002097	2.4777	.453

$[CoNO_2(NH_3)_5][Cr(CNS)_4(NH_3)_2]_2$.—*(Continued)*

B = $NaNO_3$ (204)

T, °K	c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
273.1	0.2	0.000746	2.9266	0.449
293.1	0.2	0.002228	2.4514	0.4545
B = $NaCHO_2$, Formate (204)				
273.1	0.2	0.000629	3.0006	0.449
293.1	0.2	0.001950	2.5093	0.453
B = KCl (204)				
273.1	0.2	0.000723	2.9407	0.449
293.1	0.2	0.002193	2.4573	0.454
B = KNO_3 (204)				
273.1	0.2	0.000790	2.9017	0.4495
293.1	0.2	0.002325	2.4329	0.4548
B = $KCHO_2$, Formate (204)				
273.1	0.2	0.000667	2.9752	0.449
293.1	0.2	0.002040	2.4897	0.453

$[CoH_2O(NH_3)_5][Cr(CNS)_4(NH_3)_2]_3(s) = [CoH_2O(NH_3)_5]^{+++} + 3[Cr(CNS)_4(NH_3)_2]^-$

B = $MgCl_2$; T = 273.1°K (212)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.0000663	3.8207	0.01994
.005	.0000741	3.7724	.1242
.01	.0000812	3.7326	.1747
.1	.0001184	3.5688	.549
B = $MgSO_4$; T = 273.1°K (212)			
0.01	0.000115	3.5815	0.202
.1	.000186	3.3727	.433
B = $Ca(CHO_2)_2$, Formate; T = 273.1°K (212)			
0.005	0.0000861	3.7072	0.1246
.01	.0000976	3.6527	.1747
.05	.0001200	3.5630	.386
.1	.0001360	3.5087	.549
B = Na_2SO_4; T = 273.1°K (212)			
0.005	0.000110	3.6008	0.1250
.01	.000126	3.5418	.1754
.05	.000198	3.3455	.389
B = KCl; T = 273.1°K (212)			
0.01	0.0000732	3.7777	0.102
.05	.0000905	3.6855	.225
.1	.0001024	3.6319	.317
B = $K_2C_8H_4O_4$, Phthalate; T = 273.1°K (212)			
0.005	0.000123	3.5523	0.1254
.01	.000141	3.4930	.1754
.1	.000272	3.2076	.549

$Sc_2(SO_4)_3.5H_2O(s) = 2Sc^{+++} + 3SO_4^{--} + 5H_2O(l)$

B = H_2SO_4; T = 298.1°K (1536)

$Sc_2(C_2O_4)_3.5H_2O(s)$, Oxalate = $2Sc^{+++} + 3C_2O_4^{--} + 5H_2O(l)$

B = HCl; T = 298.1 and 323.1°K (991, 1324)

B = H_2SO_4; T = 298.1°K (1536)

B = $(NH_4)_2C_2O_4$, Oxalate; T = 298.1°K (1536)

$YC_6H_5O_7.\frac{5}{2}H_2O(s)$, Citrate = $Y^{+++} + C_6H_5O_7^{---} + \frac{5}{2}H_2O(l)$

B = $C_6H_8O_7$, Citric acid (642)

$Y_2(C_2O_4)_3.9H_2O(s)$, Oxalate = $2Y^{+++} + 3C_2O_4^{--} + 9H_2O(l)$

B = H_2SO_4 (170, 285, 1534)

B = $(NH_4)_2C_2O_4$, Oxalate (170)

B = $(CH_3NH_3)_2C_2O_4$, Methylamine oxalate (508)

B = $(C_2H_5NH_3)_2C_2O_4$, Ethylamine oxalate (508)

B = $[(C_2H_5)_3NH]_2C_2O_4$, Triethylamine oxalate (508)

B = Na_2SO_4 (693)

$Y_2(C_3H_2O_4)_3.8H_2O(s)$, Malonate = $2Y^{+++} + 3C_3H_2O_4^{--} + 8H_2O(l)$

B = $C_3H_4O_4$, Malonic acid; T = 293.1°K (642)

B = $(NH_4)_2C_3H_2O_4$, Malonate; T = 293.1°K (642)

$Y_2(C_4H_4O_6)_3.5H_2O(s)$, Tartrate = $2Y^{+++} + 3C_4H_4O_6^{--} + 5H_2O(l)$

B = $(NH_4)_2C_4H_4O_6$, Tartrate; T = 293.1°K (642)

$La(IO_3)_3(s) = La^{+++} + 3IO_3^-$

B = $La(NO_3)_3$; T = 298.1°K (572)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.001030	2.6293	0.0786
.00066667	.0008430	2.6530	.0979
.0016667	.0007967	2.6181	.1216
.0033333	.0007825	2.5685	.1572
.016667	.0008320	2.3913	.3240
.033333	.0009363	2.2799	.4534
.06684	.0011195	2.1473	.6385
B = $La(NO_3)_3.2NH_4NO_3$; T = 298.1°K (572)			
0.005268	0.000951	2.4601	0.2208
.010536	.0010156	2.3714	.3006
.02107	.0011367	2.2638	.4187
.03161	.0012303	2.1956	.5101
.039366	.0013061	2.1529	.5680
.07873	.0016016	2.0125	.8046
.15747	.0020551	1.8568	1.125
.31495	.0028968	1.5702	1.593
B = $NaNO_3$; T = 298.1°K (572)			
0.001	0.001043	2.6238	0.0852
.002	.001056	2.6185	.0913
.01	.00115	2.5815	.1300
.025	.0013093	2.5250	.1812
.05	.001492	2.4684	.2424
.1	.001748	2.3996	.3324
.2	.0020873	2.3226	.4610
.4	.0024657	2.2502	.6440
.8	.0032487	2.1305	.9052
1.6	.0043114	2.0075	1.275
3.2	.0045657	1.9831	1.796
B = $NaIO_3$; T = 298.1°K (572)			
0.0000913	0.0009572	2.6511	0.0764
.000456	.0008507	2.6588	.0746
.000913	.0007658	2.6491	.0756
.001826	.0006016	2.6352	.0737
.003653	.0002973	2.6386	.0725
.004533	.0002017	2.6408	.0758
.006799	.0001468	2.5635	.0877
B = KIO_3; T = 298.1°K (572)			
0.000099	0.0009476	2.6519	0.0761
.0004957	.0008488	2.6555	.0748
.0009914	.0007488	2.6492	.0741
.0019828	.0005632	2.6387	.0724
.0039656	.0002633	2.6371	.0745

$La_2(SO_4)_3.9H_2O(s) = 2La^{+++} + 3SO_4^{--} + 9H_2O(l)$

B = H_2SO_4; T = 298.1°K (1534, 1536)

m_B	S_A	$\log (1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0	0.04497	0.9404	0.8213
.2624	.05387	.6107	1.263
.5735	.05742	.4525	1.607
1.1608	.05991	.2923	2.093
1.854	.04762	.2282	2.543
2.396	.03774	.2093	2.785
3.873	.01886	.2128	3.450
5.992	.010096	.2100	4.257
8.571	.008912	.1389	5.084
10.84	.007765	.1042	5.715

B = $(NH_4)_2SO_4$; T = 291.1°K (51, 52, 53)

B = Na_2SO_4; T = 291.1°K (51, 52, 53)

B = K_2SO_4; T = 289.6°K (51, 52, 53)

$La_2(C_2O_4)_3.9H_2O(s)$, Oxalate = $2La^{+++} + 3C_2O_4^{--} + 9H_2O(l)$

B = H_2SO_4; T = 293.1°K (170); T = 298.1°K (1534)

B = HNO_3; T = 288.1°K (1301.5)

B = $C_2H_2O_4$, Oxalic acid; T = 298.1°K (591)

B = $(NH_4)_2C_2O_4$, Oxalate; T = 293.1°K (170)

$La_2(C_3H_2O_4)_3.5H_2O(s)$, Malonate = $2La^{+++} + 3C_3H_2O_4^{--} + 5H_2O(l)$

B = $C_3H_4O_4$, Malonic acid (643)

B = $(NH_4)_2C_3H_2O_4$, Malonate (643)

$La_2(C_4H_4O_6)_3.9H_2O(s)$, Tartrate = $2La^{+++} + 3C_4H_4O_6^{--} + 9H_2O(l)$

B = $C_4H_6O_6$, Tartaric acid; T = 293.1°K (643)

B = $(NH_4)_2C_4H_4O_6$, Tartrate; T = 293.1°K (643)

$CeC_6H_5O_7.7H_2O(s)$, Citrate = $Ce^{+++} + C_6H_5O_7^{---} + 7H_2O(l)$

B = $C_6H_8O_7$, Citric acid; T = 293.1°K (642)

$Ce_2(SO_4)_3.8H_2O(s) = 2Ce^{+++} + 3SO_4^{--} + 8H_2O(l)$

B = H_2SO_4; T = 298.1°K (1534)

B = $(NH_4)_2SO_4$; T = 289.1°K (51, 52, 53)

B = Na_2SO_4; T = 289.1°K (51, 52, 53)

B = K_2SO_4; T = 289.1°K (51, 52, 53)

$Ce_2(C_2O_4)_3.9H_2O(s)$, Oxalate = $2Ce^{+++} + 3C_2O_4^{--} + 9H_2O(l)$

B = H_2SO_4; T = 293.1°K (170); T = 298.1°K (591, 1534)

B = $C_2H_2O_4$, Oxalic acid; T = 298.1°K (591, 1534)

B = $(NH_4)_2C_2O_4$, Oxalate; T = 293.1°K (170)

$Ce_2(C_3H_2O_4)_3.6H_2O(s)$, Malonate = $2Ce^{+++} + 3C_3H_2O_4^{--} + 6H_2O(l)$

B = $C_3H_4O_4$, Malonic acid; T = 293.1°K (642)

B = $(NH_4)_2C_3H_2O_4$, Malonate; T = 293.1°K (642)

$Ce_2(C_4H_4O_6)_3.6H_2O(s)$, Tartrate = $2Ce^{+++} + 3C_4H_4O_6^{--} + 6H_2O(l)$

B = $C_4H_6O_6$, Tartaric acid; T = 293.1°K (642)

B = $(NH_4)_2C_4H_4O_6$, Tartrate; T = 293.1°K (642)

$Pr_2(C_2O_4)_3.10H_2O(s)$, Oxalate = $2Pr^{+++} + 3C_2O_4^{--} + 10H_2O(l)$

B = H_2SO_4; T = 293.1°K (170)

B = $(NH_4)_2C_2O_4$, Oxalate; T = 293.1°K (170)

$Nd_2(C_2O_4)_3.10H_2O(s)$, Oxalate = $2Nd^{+++} + 3C_2O_4^{--} + 10H_2O(l)$

B = H_2SO_4; T = 293.1°K (170)

B = $(NH_4)_2C_2O_4$, Oxalate; T = 293.1°K (170)

B = $(CH_3NH_3)_2C_2O_4$, Methylamine oxalate; T = 293.1°K (508)

B = $(C_2H_5NH_3)_2C_2O_4$, Ethylamine oxalate; T = 293.1°K (508)

B = $[(C_2H_5)_3NH]_2C_2O_4$, Triethylamine oxalate; T = 293.1°K (508)

B = $Nd(NO_3)_3$; T = 298.1°K (694)

$Sa_2(C_2O_4)_3.10H_2O(s)$, Oxalate = $2Sa^{+++} + 3C_2O_4^{--} + 10H_2O(l)$

B = HCl; T = 298.1°K (991, 1324); T = 323.1°K (991); T = B.P. (996)

B = H_2SO_4; T = 298.1°K (991, 1534, 1536); T = 323.1°K (991)

$Gd_2(SO_4)_3.8H_2O = 2Gd^{+++} + 3SO_4^{--} + 8H_2O(l)$

B = H_2SO_4; T = 298.1°K (1534)

B = Na_2SO_4; T = 298.1°K (113)

$Gd_2(C_2O_4)_3.10H_2O(s)$, Oxalate = $2Gd^{+++} + 3C_2O_4^{--} + 10H_2O(l)$

B = HCl; T = 298.1°K (1324)

B = H_2SO_4; T = 298.1°K (1534, 1536)

B = $(CH_3NH_3)_2C_2O_4$, Methylamine oxalate; T = 298.1°K (508)

B = $(C_2H_5NH_3)_2C_2O_4$, Ethylamine oxalate; T = 298.1°K (508)

B = $[(C_2H_5)_3NH]_2C_2O_4$, Triethylamine oxalate; T = 298.1°K (508)

$Er_2(SO_4)_3.8H_2O(s) = 2Er^{+++} + 3SO_4^{--} + 8H_2O(l)$

B = H_2SO_4; T = 298.1°K (1534, 1536)

$Er_2(C_2O_4)_3.14H_2O(s)$, Oxalate = $2Er^{+++} + 3C_2O_4^{--} + 14H_2O(l)$

B = H_2SO_4; T = 298.1°K (1534)

$Yb_2(C_2O_4)_3.10H_2O(s)$, Oxalate = $2Yb^{+++} + 3C_2O_4^{--} + 10H_2O(l)$

B = H_2SO_4 (285)

B = $(NH_4)_2C_2O_4$, Oxalate (285)

B = $(CH_3NH_3)_2C_2O_4$, Methylamine oxalate (508)

B = $(C_2H_5NH_3)_2C_2O_4$, Ethylamine oxalate (508)

B = $[(C_2H_5)_3NH]_2C_2O_4$, Triethylamine oxalate (508)

$BeSO_4.6H_2O = Be^{++} + SO_4^{--} + 6H_2O(l)$

B = H_2SO_4; T = 298.1°K (1535)

$BeC_2O_4.3H_2O(s)$, Oxalate = $Be^{++} + C_2O_4^{--} + 3H_2O(l)$

B = H_2SO_4; T = 298.1°K (1536)

B = $C_2H_2O_4$, Oxalic acid; T = 298.1°K (1536)

$Mg(OH)_2(s) = Mg^{++} + 2OH^-$

B = NaOH + NaCl (942)

$MgCO_3.3H_2O(s) = Mg^{++} + CO_3^{--} + 3H_2O(l)$

B = NaCl; T = 296.1°K; air free from $CO_2(g)$ (247)

m_B	S_A	m_B	S_A
0.0	0.002094	1.887	0.00720
0.4846	.005015	2.663	.006816
1.039	.006371	4.339	.005965

B = Na_2SO_4; T = 297.1°K; air free from $CO_2(g)$ (247)

m_B	S_A	m_B	S_A
0.0	0.002569	1.165	0.01501
.1776	.006981	1.896	.01670
.3886	.009899	2.076	.01681
.6843	.01229	2.296	.01759

$MgCO_3.3H_2O$.—(*Continued*)

B = Na_2CO_3; T = 298.1°K; air free from CO_2(g) (247)

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0	0.002654	2.5761	0.1031
.2188	.003428	1.5591	.8186
.4805	.006069	1.2648	1.211
.8192	.01047	1.0305	1.581
1.213	.01573	0.8569	1.924
1.540	.01969	.7564	2.168
1.745	.02342	.6915	2.309
2.065	.02822	.6143	2.512

For T = 308.6°K, *v.* (247)

B = $KHCO_3$; T = 288.11, 298.1 and 308.1°K (33, 34)

$MgC_2O_4.2H_2O$(s), Oxalate = $Mg^{++} + C_2O_4^{--} + 2H_2O$(l)

B = HCl; T = 298.1°K (1324)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.003426	2.4652	0.1171
.0005	.003778	2.4227	.1229
.001	.004124	2.3847	.1323
.00125	.004293	2.3672	.1357
.0025	.005129	2.2899	.1517
.005	.006793	2.1679	.1794
.01	.010115	1.9960	.2246

B = $MgSO_4$; T = 298.1°K (1489)

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0	0.00307	2.5129	0.1108
.00272	.00235	2.4620	.1424
.00491	.00215	2.4094	.1680

$Ca(OH)_2$(s) = $Ca^{++} + 2OH^-$

m = 0.0210 at 298.1°K (589)

B = NH_4Cl; T = 298.1°K (1080)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.02022	1.4934	0.2463
.02176	.02908	1.3357	.3302
.04532	.03923	1.2057	.4037
.08703	.05968	1.0234	.4886

B = $C_3H_8O_3$, Glycerol; T = 298.1°K (243.5)

m_B	S_A	m_B	S_A
0.0	0.02089	2.372	0.1048
.3946	.03296	5.752	.2422
2.109	.09018	13.70	.5479

B = C_6H_6O, Phenol; T = 298.1°K (987.5)

0.0	0.01666	1.224	1.271
.224	.1288	1.541	1.541
.7126	.7697		

B = $CaCl_2$; T = 298.1°K (1329)

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.4766	0.018985	1.0486	1.2193
1.002	.02281	0.8903	1.7533
1.61	.02947	.7481	2.2218
2.001	.032308	.6923	2.4697

B = $CaBr_2$; T = 298.1°K (1007)

0.5124	0.02342	0.9765	1.2677
.7984	.02091	.9479	1.5676
1.189	.02541	.8344	1.9060
1.308	.02072	.8805	1.9964

B = CaI_2; T = 298.1°K (1007)

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.3425	0.01493	1.1655	1.0354
.7184	.01924	0.9872	1.4875
1.184	.02093	.8918	1.9013
1.354	.02417	.8307	2.0333

B = $Ca(NO_3)_2$; T = 298.1°K (59)

0.0	0.02053	1.4873	0.2482
.2134 (245)	.01342	1.2622	.8248
.31	.01835	1.1181	.9925
.63	.021156	0.9778	1.398
.97456	.02471	.8708	1.752
1.16	.02689	.8214	1.887
1.493	.02985	.7551	2.138
2.217	.03956	.6166	2.602
3.003	.05150	.4964	3.028
4.193	.07346	.3452	3.577
4.901	.09876	.2366	3.873

B = $CaSO_4$; T = 298.1°K (239, 240)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.0208	1.4812	0.2498
.002872	.02035	1.4716	.2693
.004892	.02051	1.4563	.2848
.007015	.02167	1.4228	.3051
.008918	.02215	1.4049	.3195
.01167	.02179	1.3989	.3348

B = NaOH; T = 293.1°K (318)

0.0	0.02087	1.4797	0.2502
.01	.01677	1.4996	.2456
.04	.01017	1.4771	.2655
.0666	.006956	1.4486	.2957
.125	.003210	1.4189	.3669
.2	.001962	1.3628	.4537
.5	.0003567	1.3495	.7079

For 323.1, 343.1 and 373.1°K, *v.* (318)

B = NaCl (942)

B = KCl; T = 323.1°K (757)

m_B*	S_A*	m_B*	S_A*
0.0	0.029	2.368	0.038
.236	.042	2.841	.036
.947	.045	3.315	.033
1.894	.042	3.552	.017

* Per 1000 g solution.

$CaSO_4.2H_2O$(s) = $Ca^{++} + SO_4^{--} + 2H_2O$(l)

B = HCl; T = 298.1°K (919)

B = NH_4Cl; T = 298.1°K (243)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.2019	0.02865	1.5428	0.5608
.4561	.03952	1.4031	.7839
.8729	.05194	1.2845	1.040
1.766	.06464	1.1895	1.423
2.798	.07566	1.1211	1.761
3.712	.0797	1.0985	2.008
3.925	.07992	1.0973	2.060
5.140	.07787	1.1086	2.335
6.074	.06905	1.1608	2.520
7.015	.05421	1.2659	2.684

B = NH_4NO_3; T = 298.1°K (243)

0.1249	0.02336	1.6315	0.4672
.3123	.02887	1.5395	.6539
.6871	.04261	1.3704	.9260

B = NH_4NO_3.—*(Continued)*

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
1.249	0.0572	1.2426	1.234
1.874	.06523	1.1855	1.461
2.498	.07236	1.1405	1.669
3.748	.07934	1.1005	2.016
4.997	.08374	1.0771	2.309
9.369	.08962	1.0476	3.119
12.49	.08675	1.0617	3.583
17.49	.07361	1.1330	4.216

B = $(NH_4)_2SO_4$; T = 298.1°K (1414.5)

0.0009766	0.01500	1.8099	0.2508
.001953	.01466	1.8067	.2540
.007812	.01327	1.7766	.2766
.01563	.01218	1.7350	.3094
.03125	.01131	1.6587	.3728
.06250	.01058	1.5558	.4797
.1250	.01069	1.4192	.6467
.2500	.01188	1.2535	.8930
.7500	.01712	0.9408	1.522
1.500	.02446	.7142	2.144
3.00	.03305	.4995	3.022

B = $NH_4C_2H_3O_2$, Acetate; T = 298.1°K (952)

B = $CuSO_4$; T = 298.1°K (74, 571)

m_B	S_A	$\log (1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0 (571)	0.01535	1.8138	0.2478
.00718	.01521	1.7339	.2993
.01254 (571)	.01360	1.7248	.3233
.0224	.01464	1.6329	.3849
.03793	.0143	1.5634	.4571
.04561	.01365	1.5476	.4869
.05010 (571)	.01239	1.5557	.5000
.09286	.01293	1.4320	.6505
.10100 (571)	.01242	1.4255	.6735
.1236	.01275	1.3799	.7388
.1853	.0124	1.3053	.8893
.21200 (571)	.01329	1.2591	.9492
.2469	.0126	1.2428	1.019
.3094	.01281	1.1922	1.135
.3689	.01309	1.1499	1.236
.6145	.0142	1.0246	1.586
.9227	.0151	0.9245	1.937
.97710 (571)	.01654	.8921	1.994
1.2332	.01531	.8587	2.235
1.4220	.01548	.8263	2.398

B = $MgCl_2$; T = 299.1°K (246)

0.0	0.01537	1.8133	0.2479
.08947	.03141	1.5029	.6087
.2025	.04203	1.3764	.9890
.4953	.05638	1.1488	1.486
1.3114	.06514	1.1861	2.347
2.289	.05082	1.2939	3.059
3.895	.02239	1.6505	3.958
5.272	.01162	1.9348	4.597

B = $MgSO_4$

T = 298.1°K (571)

0.00502	0.01441	1.7762	0.2788
.01012	.01362	1.7451	.3082
.01528	.01310	1.7150	.3369

T = 298.1°K (239)

0.0265	0.0119	1.6700	0.3919
.0530	.01106	1.5748	.5061
.0884	.01081	1.4849	.6299

B = $MgSO_4$.—*(Continued)*

m_B	S_A	$\log (1/m_\pm)$	$\mu^{\frac{1}{2}}$

T = 298.1°K.—*(Continued)*

0.1774	0.01086	1.3446	0.8678
.3551	.01142	1.1355	1.370
.5312	.01177	1.0972	1.474
.7144	.01183	1.0330	1.704
1.077	.01208	0.9404	2.087
1.683	.01065	.8719	2.603
2.270	.00809	.8672	3.019
3.114	.00388	.9586	3.532

B = $Mg(NO_3)_2$; T = 298.1°K (1335)

0.0	0.01537	1.8133	0.2487
.09845	.04284	1.3682	.7518
.1985	.05899	1.2292	1.050
.4025	.07525	1.1235	1.382
.8327	.10467	0.9802	1.936
1.2923	.11366	.9444	2.371
1.7976	.12436	.9054	2.773
2.4251	.13374	.8737	3.199

B = $Ca(OH)_2$; T = 298.1°K (240)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.01562	1.8063	0.2500
.001106	.01491	1.8109	.2509
.003139	.01409	1.8073	.2622
.006224	.01361	1.7844	.2704
.0109	.01265	1.7629	.2886
.01675	.01200	1.7310	.3134
.02179*	.011665	1.7043	.3349

* Solid phase $CaSO_4.2H_2O(s) + Ca(OH)_2(s)$.

B = $CaCl_2$; T = 298.1°K (246)

0.0	0.01510	1.8210	0.2458
.06747	.009138	1.5792	.4887
.1077	.008675	1.4980	.5981
.2322	.00805	1.3567	.8536
.2887	.007933	1.3141	.9475
.4642	.007463	1.2267	1.193
.8741	.006178	1.1322	1.627
1.736	.003416	1.1130	2.285
2.525	.001491	1.2119	2.753
3.314	.000235	1.5743	3.153

B = $Ca(NO_3)_2$; T = 298.1°K (1338)

m_B	S_A	$\log (1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0	0.01534	1.8142	0.2477
.1542	.00921	1.4114	.7066
.3107	.00897	1.2712	.9839
.6303	.00862	1.6295	1.388
1.301	.0073	1.5100	1.983
2.0235	.0062	1.4502	2.465
2.816	.00483	1.4329	2.908
3.679	.00357	1.4405	3.377
4.102	.00315	1.4442	3.508

B = NaCl; T = 298.1°K (237)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.01558	1.8074	0.2497
1.559	.04889	1.3107	1.325
2.463	.05273	1.2779	1.635
2.537	.05262	1.2788	1.657
3.019	.05229	1.2815	1.797
3.913	.04991	1.3018	2.003
4.519	.04773	1.3212	2.170
5.482	.04198	1.3769	2.377

For 288.1, 299.1, 303.1, 335.1, 343.1 and 355.1°K, *v.* (237)

$CaSO_4.2H_2O$.—*(Continued)*

B = $NaNO_3$; T = 298.1°K (1338)

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0	0.01534	1.8141	0.2477
.298	.03165	1.4996	.6516
.596	.0413	1.3840	.8726
1.237	.05483	1.2609	1.207
2.544	.06983	1.1559	1.680
4	.07729	1.1118	2.076
9.337	.07664	1.1155	3.105
10.582	.07303	1.1365	3.298

B = Na_2SO_4; T = 298.1°K (242)

B = KNO_3; T = 298.1°K (571, 1338)

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0	0.01534	1.8141	0.2477
.02766 (571)	.01812	1.7419	.3164
.05293 (571)	.02019	1.6949	.3656
.10380 (571)	.02130	1.6715	.4347
.1245	.02432	1.6140	.4710
.2508	.03039	1.5171	.6102
.53	.03952	1.4031	.7669
1.035	.05271	1.2781	1.116
1.587	.06217	1.2064	1.355
2.163	.06986	1.1557	1.563

B = K_2SO_4; T = 298.1°K (242)

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0	0.01537	1.8133	0.2480
.02808	.01179	1.6639	.3625
.02928	.01149	1.6646	.3658
.05673	.01069	1.5711	.4615
.1638	.01147	1.3506	.7330
.1774	.01164	1.3287	.7608

$CaSO_4.2H_2O$, Selenite = $Ca^{++} + SO_4^{--} + 2H_2O(l)$

B = $MgSO_4$; T = 298.1°K (571)

m_B	S_A	m_B	S_A
0.0	0.01521	0.02755	0.01210
0.0	.01514	.05248	.01145
.01114	.01314	.10288	.010985

$CaC_2O_4.H_2O(s)$, Oxalate = $Ca^{++} + C_2O_4^{--} + H_2O(l)$

B = $C_2H_4O_2$, Acetic acid; T = 299–300°K (612, 613); *cf.* (599)

c_B	s_A	c_B	s_A
0.0	0.0002325	2.89	0.000793
0.58	0.0006564	5.79	0.000875

$CaC_4H_4O_4.H_2O(s)$, Succinate = $Ca^{++} + C_4H_4O_4^{--} + H_2O(l)$

B = $MgC_4H_4O_4$, Succinate; T = 298.1°K (1491)

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0	0.08252	0.5834	0.5745
.04121	.07769	.5172	.6896
.06179	.07474	.4957	.7390
.08230	.07340	.4709	.7892
.1231	.07173	.4273	.8827
.1631	.07087	.3905	.9675

B = $Na_2C_4H_4O_4$, Succinate; T = 298.1°K (1491)

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.00826	0.08013	0.5748	0.5875
.0506	.07103	.5318	.6602
.1014	.06495	.4830	.7510
.1526	.06138	.4407	.8386
.2560	.05757	.3717	.9992

$CaC_4H_4O_6.4H_2O(s)$, Tartrate = $Ca^{++} + C_4H_4O_6^{--} + 4H_2O(l)$

B = $C_2H_4O_2$, Acetic acid; T = 299–300°K (612, 613)

B = $C_4H_6O_6$, Tartaric acid; T = 291.1°K (1117)

c_B	s_A	c_B	s_A
0.0	0.001462	0.06	0.00810
.00666	.00350	.06667	.00848
.01333	.00447	.07333	.00903
.02	.00517	.08	.00915
.026667	.00581	.086667	.00933
.03333	.00632	.09333	.00967
.04	.00678	.10000	.00989
.04666	.00719	.10666	.0102
.05333	.00758		

B = $CaCl_2$; Tartrate; T = 291.1°K (1117)

c_B	s_A	c_B	s_A
0.00453	0.000776	0.0498	0.000595
.00905	.000699	.0679	.0006573
.0226	.0006531	.0905	.0006804
.0317	.0006381	.2263	.0007004
.0408	.0005916	.4526	.0008614
.0453	.0005927		

B = $K_2C_4H_4O_6$, Tartrate; T = 291.1°K (1117)

c_B	s_A	c_B	s_A
0.0067	0.0006400	0.02	0.0008572
.0091	.0006169	.1	.001011
.01	.0006030	.2	.001172
.0111	.0005762		

$Sr(OH)_2.8H_2O(s) = Sr^{++} + 2OH^- + 8H_2O(l)$

B = $SrCl_2$; T = 298.1°K (1007)

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0	0.068	0.9670	0.452
.9113	.09580	.3878	1.738
1.806	.0938	.3916	2.387
3.217	.1606	.1526	3.183

B = $SrBr_2$; T = 298.1°K (1007)

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.7914	0.07667	0.5634	1.614
1.113	.08053	.5159	1.892
1.534	.08844	.4315	2.206
2.279	.11107	.3095	2.678
2.582	.1259	.2550	2.850
2.808	.1386	.2149	2.973

B = SrI_2; T = 298.1°K (1007)

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.8496	0.07137	0.5755	1.662
1.263	.0736	.5547	2.003
1.929	.08853	.4164	2.460
2.898	.09548	.3207	2.997

B = $Sr(SH)_2$; T = 298.1°K (1007)

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.5194	0.06338	0.6762	1.322
1.066	.06546	.5709	1.842
1.536	.06026	.5450	2.188
1.855	.06082	.5159	2.397
2.109	.05713	.5162	2.549

B = $Sr(NO_3)_2$; T = 298.1°K (1430)

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0	0.08	0.8962	0.490
.0	.085	.8751	.505
.2102	.07527	.7297	.925
.2972	.0762	.6872	1.059
.4233	.07816	.6373	1.227
.6038	.08106	.5815	1.433
.8486	.0878	.5131	1.673
1.126	.09167	.4626	1.911
1.531	.0994	.3969	2.212

B = $Sr(NO_3)_2$:—(*Continued*)

m_B	S_A	$\log(1/m_\pm)$	$\mu^{\frac{1}{2}}$
2.081	0.1158	0.3096	2.567
2.852	.1419	.2059	2.997
3.827	.1698	.1121	3.450

$SrSO_4(s) = Sr^{++} + SO_4^{--}$

B = $NH_4C_2H_3O_2$, Acetate; T = 298.1°K (952)

c_B	s_A	$\log(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.000822	3.0851	0.0574
2.13	.002455	2.6099	1.463
5.34	.003985	2.3995	2.313
10.68	.005128	2.2900	3.268
21.37	.00626	2.2035	4.623

B = $MgCl_2$; Room temp. (1474)

m_B	S_A	$\log(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.1701	0.001099	2.959	0.4177
.4412	.001167	2.9329	.6676
1.657	.001525	2.8167	1.290

B = $CaCl_2$; Room temp. (1474)

0.8559	0.001047	2.9800	0.9274
1.626	.001208	2.9179	1.277
4.58	.001401	2.8535	2.141

B = NaCl; Room temp. (1474)

1.576	0.0009826	3.0076	1.255
3.147	.001409	2.8510	1.776
4.873	.001267	2.8972	2.219

B = KCl; Room temp. (1474)

1.134	0.001140	2.9430	1.051
1.923	.001203	2.9197	1.388
2.96	.001670	2.7772	1.723

$SrC_2O_4.H_2O(s)$, Oxalate = $Sr^{++} + C_2O_4^{--} + H_2O(l)$

B = $C_2H_4O_2$, Acetic acid; T = 299–300°K (612, 613)

c_B	s_A	c_B	s_A
0.0	0.000464	3.86	0.003094
.58	.002713	5.79	.002568
1.45	.003208	16.26	.000320
2.89	.003311		

$SrC_4H_4O_4(s)$, Succinate = $Sr^{++} + C_4H_4O_4^{--}$

B = $Na_2C_4H_4O_4$, Succinate; T = 298.1°K (1489)

m_B	S_A	$\log(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0	0.02013	1.6962	0.2838
.00938	.01740	1.6658	.3126
.01875	.01535	1.6552	.3430
.03751	.01322	1.5917	.4067
.05582	.01221	1.5403	.4651
.07457	.01143	1.5037	.5190

$SrC_4H_4O_5(s)$, Malate = $Sr^{++} + C_4H_4O_5^{--}$

B = $SrCl_2$; T = 298.1°K (1489)

m_B	S_A	$\log(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0	0.03050	1.5157	0.3493
.01828	.02523	1.4798	.3946
.03103	.02349	1.4464	.4325
.06149	.02019	1.3914	.5150

$SrC_4H_4O_6.3H_2O(s)$, Tartrate = $Sr^{++} + C_4H_4O_6^{--} + 3H_2O(l)$

B = $C_2H_4O_2$, Acetic acid; T = 299–300°K (613)

c_B	s_A	c_B	s_A
0.0	0.00783	3.77	0.03626
.565	.02338	5.65	.03393
1.425	.02978	16.89	.00634
2.85	.03435		

$Ba(OH)_2.8H_2O(s) = Ba^{++} + 2OH^- + 8H_2O(l)$

B = $BaCl_2$; T = 303.1°K (1328)

m_B	S_A	$\log(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0	0.3446	0.2619	1.017
.5848	.3282	.1352	1.655
.7492	.3638	.0765	1.827
1.054	.3856	.0234	2.071
1.128	.3923	.0096	2.135

B = $BaBr_2$; T = 298.1°K (1007)

0.0	0.2765	0.3576	0.9163
.5478	.2786	.1969	1.575
.7967	.2858	.1504	1.802
1.186	.3196	.0703	2.125
1.375	.3304	.0427	2.262

B = BaI_2; T = 298.1°K (1007)

0.6025	0.2717	0.1960	1.620
1.065	.2877	.1162	2.015
1.788	.3069	.0342	2.507
1.905	.3698	−0.0316	2.612

B = $Ba(NO_3)_2$; T = 298.1°K (1110)

0.0	0.2474	0.4059	0.8615
.01645	.2474	.3966	.8896
.05547	.2509	.3709	.9587
.07192	.2509	.3633	.9841
.09679	.2549	.3463	1.027
.1327	.2584	.3270	1.083
.2165	.2653	.2883	1.202
.2888	.2722	.2598	1.293
.3906	.2843	.2204	1.423
.4392	.2895	.2040	1.478

B = LiCl; T = 298.1°K (608)

c_B	s_A	$\log(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.2775	0.3560	0.9112
.75	.3725	.2055	1.366
1.42	.4685	.1286	1.681
2.3	.668	−0.02531	2.074

B = NaOH; T = 303.1°K (1328)

m_B	S_A	$\log(1/m_\pm)$	$\mu^{\frac{1}{2}}$
1.779	0.0899	0.1540	1.431
2.52	.0632	.1187	1.646
3.853	.0427	.0362	1.995
4.787	.0409	.0044	2.216
8.042	.0396	−0.1389	2.857
11.64	.0992	−0.3950	3.454
12.81	.1821	−0.4998	3.654

B = NaCl; T = 298.1°K (608)

c_B	s_A	$\log(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.73	0.315	0.3010	1.271
1.43	.3495	.2558	1.576
2.82	.403	.1940	2.007

$Ba(OH)_2.8H_2O$.—(*Continued*)

B = KCl; T = 298.1°K (608)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.86	0.3255	0.2876	1.355
1.75	.330	.2808	1.650
3.4	.388	.2105	2.136
B = RbCl; T = 298.1°K (608)			
1.25	0.324	0.2887	1.491

$Ba(BrO_3)_2.H_2O(s) = Ba^{++} + 2BrO_3^- + H_2O(l)$

B = $Mg(NO_3)_2$; T = 298.1°K (570)

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0	0.02017	1.4946	0.246
.0503	.02644	1.3770	.480
B = $Ba(NO_3)_2$; T = 298.1°K (570)			
0.01255	0.01846	1.4613	0.305
.02515	.01748	1.4277	.357
.05027	.01641	1.3812	.447
.10064	.01560	1.3035	.5905
B = $KBrO_3$; T = 298.1°K (570)			
0.02509	0.01332	1.4827	0.255
.05023	.00873	1.4659	.276
.10058	.00441	1.4225	.337
B = KNO_3; T = 298.1°K (570)			
0.02512	0.02204	1.4561	0.302
.05032	.02315	1.4344	.346
.10059	.02627	1.3798	.4235

$Ba(IO_3)_2(s) = Ba^{++} + 2IO_3^-$

B = $Ba(NO_3)_2$; T = 298.1°K (573)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.000790	2.9017	0.0487
.0005	.000681	2.8867	.0596
.0010	.000606	2.8758	.0694
.0025	.000488	2.8486	.0947
.0100	.000337	2.7757	.1761
.0250	.000307	2.6734	.2751
.0500	.000283	2.5974	.3885
.1000	.000279	2.5017	.548
B = KIO_3; T = 298.1°K (573)			
0.002	0.000812	2.8894	0.0666
.010	.000913	2.8392	.1129
.050	.001320	2.6790	.2322
.200	.001595	2.5964	.453
B = KNO_3; T = 298.1°K (573)			
0.000106	0.000755	2.9017	0.0498
.000530	.000621	2.9033	.0541
.001061	.000471	2.9080	.0595

$BaSO_4(s) = Ba^{++} + SO_4^{--}$

B = HCl (1104)

B = HNO_3 (1104)

B = H_2SO_4; T = 293.1°K (1512)

B = NH_4Cl; T = 287°K (371)

B = $NH_4C_2H_3O_2$, Acetate; T = 298.1°K (660, 952)

B = $FeCl_3$; T = 293–298°K (446)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.006164	0.0002485	3.6048	0.1949
.01541	.0003085	3.5107	.306
.03082	.0004927	3.3074	.4225
.06164	.000527	3.2782	.6099
.1541	.0006427	3.1919	.9629

B = $FeCl_3$.—(*Continued*)

c_B	s_A	log $(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.3082	0.0006855	3.1639	1.361
.6164	.0007284	3.1376	1.924
B = $AlCl_3$; T = 293–298°K (446)			
0.00749	0.0001414	3.8496	0.2135
.01873	.000184	3.7352	.3363
.03746	.0002571	3.5899	.4752
.07492	.0004027	3.3950	.6716
.1873	.000497	3.3037	1.107
.3746	.000728	3.1379	1.500
.7492	.0007498	3.1250	2.121
B = $MgCl_2$; T = 293–298°K (446)			
0.01045	0.0001285	3.8911	0.1785
.02613	.0001285	3.8911	.2809
.05225	.0001414	3.8495	.3966
.1045	.0001414	3.8495	.5604
.2613	.0002142	3.6692	.8859
.5225	.0002142	3.6692	1.253
1.045	.0002142	3.6692	1.771

$BaC_2O_4.\frac{1}{2}H_2O(s)$, Oxalate = $Ba^{++} + C_2O_4^{--} + \frac{1}{2}H_2O(l)$

B = $C_2H_4O_2$, Acetic acid; T = 299–300°K (612)

B = NH_4Cl; T = 289.1°K (253)

B = NaCl; T = 289.1°K (253)

B = KCl; T = 289.1°K (253)

$BaC_4H_4O_4(s)$, Succinate = $Ba^{++} + C_4H_4O_4^{--}$

B = $MgC_4H_4O_4$, Succinate; T = 298.1°K (1489)

m_B	S_A	log $(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0	0.01570	1.8041	0.2508
.0077	.01397	1.7276	.2944
.01538	.01294	1.6613	.3366
.03074	.01155	1.565	.4101
.04620	.01065	1.4877	.4770
.06149	.01024	1.4261	.5356
B = $CaC_4H_4O_4$, Succinate; T = 298.1°K (1489)			
0.00798	0.01383	1.7273	0.2954
.01597	.01275	1.6476	.3389
.03193	.01155	1.5536	.4170
B = $Na_2C_4H_4O_4$, Succinate; T = 298.1°K (1489)			
0.00798	0.01307	1.7457	0.2761
.01575	.01154	1.6886	.3056
.03149	.00987	1.591	.4049
.04726	.00913	1.4992	.4223

$BaC_4H_4O_6(s)$, Tartrate = $Ba^{++} + C_4H_4O_6^{--}$

B = $C_2H_4O_2$, Acetic acid; T = 299–300°K (612)

c_B	s_A	c_B	s_A
0.0	0.0023	3.77	0.01308
.565	.00806	5.65	.01306
1.425	.01092	16.85	.00153
2.85	.01218		

$RaSO_4(s) = Ra^{++} + SO_4^{--}$

B = H_2SO_4

c_B	$s_A \times 10^8$	c_B	$s_A \times 10^8$
T = 298.1°K (893)			
0.0	6.5	10%	7.5
.005	6.3	15%	7.5
.05	6.8	25%	7.1
.5	6.8	30%	7.1

B = H_2SO_4.—(*Continued*)

c_B	$s_A \times 10^8$	c_B	$s_A \times 10^8$
45%	5.9	65%	20.0
50%	6.5	70%	>245
55%	10.5	80%	>245
60%	19.5	90%	>245

T = 308.1°K (893)

0.005	9.7	25%	10.2

T = 318.1°K (893)

25%	15.5		

$Li_2CO_3(s) = 2Li^+ + CO_3^{--}$

B = NH_4Cl; T = 298.1°K (469)

c_B	s_A	$\log (1/c_\pm)$*	$\mu_c^{\frac{1}{2}}$*
0.0	0.1708	0.5670	0.7156
.1	.1951	.5090	.8278
.25	.2339	.4302	.9748
.5	.283	.3475	1.161
.75	.3135	.3031	1.300
1	.3405	.2672	1.422
1.5	.3732	.2273	1.619
2	.387	.2116	1.778
4	.3941	.2037	2.276

* Values of $\log (1/c_\pm)$ and $\mu_c^{\frac{1}{2}}$ not corrected for hydrolysis.

B = $(NH_4)_2SO_4$; T = 298.1°K (469)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.125	0.253	0.3962	1.067
.25	.3932	.2047	1.389
.5	.4902	.1089	1.724
.75	.5545	.0554	1.978
1	.587	.0306	2.182

B = NaCl; T = 298.1°K (469)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.1	0.1785	0.5474	0.7922
.25	.1846	.5331	.8965
.5	.1934	.5128	1.039
.75	.1978	.5030	1.159
1.0	.1973	.5043	1.262
1.5	.1951	.509	1.444
2	.1888	.5233	1.602

B = Na_2SO_4; T = 298.1°K (469)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.25	0.2206	0.4556	1.188
.5	.2463	.4078	1.496
.1	.2767	.3573	1.957

B = KCl; T = 298.1°K (469)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.1	0.1777	0.5496	0.7957
.25	.1795	.5453	.8880
.5	.1891	.5227	1.033
.75	.1916	.5169	1.151
1.00	.1918	.5164	1.255
1.50	.1866	.5284	1.435
2.0	.1779	.5442	1.592

B = KNO_3; T = 298.1°K (469)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.17075	0.5670	0.7157
.25	.1824	.5383	.8928
.5	.1844	.5335	1.026
.75	.1838	.5349	1.141
1	.1828	.5373	1.244
1.5	.1745	.5575	1.422
2.0	.1634	.5860	1.578

B = K_2SO_4; T = 298.1°K (469)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.125	0.2014	0.4952	0.9895
.25	.2178	.4613	1.185
.5	.2430	.4137	1.493

$Na[Co(NO_2)_2C_2O_4(NH_3)_2](s) = Na^+ + [Co(NO_2)_2C_2O_4(NH_3)_2]^-$

B = NaCl; T = 273.1°K (204)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.1	0.00928	1.4971	0.330

B = $NaNO_3$; T = 273.1°K (204)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.1	0.00972	1.4861	0.331

$KClO_3(s) = K^+ + ClO_3^-$

B = $TlClO_3$; T = 273.1, 288.1, 323.1, 373.1°K (1166)

B = KOH; T = 287–288°K (123); T = 293.1°K (201, 202)

B = KOH + H_2O_2; T = 298.1°K (236)

$c_{(KOH)}$	$c_{(H_2O_2)}$	s_A
0.0	0.0	0.675
.125	.0	.624
.250	.0	.573
.250	.015	.578
.250	.276	.584
.250	.954	.616
.250	1.073	.673
0.0	1.260	.730
0.0	1.310	.737

B = KCl; T = 287–288°K (123); T = 293.1°K (1533)

B = KBr; T = 287–288°K (123)

B = KI; T = 287–288°K (123)

B = KNO_3

c_B	s_A	c_B	s_A
T = 291.97°K (26)			
0.0	0.645	0.5	0.515
T = 292.95°K (26); for T = 287–288°K, *v.* (123)			
0.0	0.570	1.0	0.374
.125	.529	2.0	.328
.25	.492		

B = K_2SO_4; T = 287–288°K (123)

B = $K_2C_2O_4$, Oxalate; T = 287–288°K (123)

$KClO_4(s) = K^+ + ClO_4^-$

B = $HClO_4$; T = 298.3°K (1436)

m_B	S_A	$\log (1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0	0.1505	0.8225	0.3875
.01	.1443	.8262	.3928
.1	.1072	.8267	.4552
1	.0381	.7014	1.019

B = C_2H_6O, Ethyl alcohol + $HClO_4$; T = 298.3°K (1436)

% C_2H_6O	% $HClO_4$	A, Mol/1000 g soln.
93.5	0.2	0.0127
98.8	.2	.0007
98.8	2.0	.0020

B = $BaCl_2$; T = 298.1°K (162)

m_B	S_A	$\log (1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0	0.1491	0.8265	0.386
.04955	.1569	.8054	.544
.1487	.1638	.786	.781
.2997	.1693	.7714	1.034

$KClO_4$.—(*Continued*)

B = $Ba(NO_3)_2$; T = 298.1°K (162)

m_B	S_A	$\log(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0495	0.1605	0.795	0.566
.1509	.1747	.758	.792
.3037	.1902	.721	1.049

B = $NaCl$; T = 298.1°K (162)

m_B	S_A	$\log(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.1007	0.1567	0.8049	0.5073
.2994	.1658	.7804	.682
.5903	.1732	.7615	.8738

B = $NaClO_4$; T = 298.1°K (162)

m_B	S_A	$\log(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.1026	0.1122	0.8090	0.4572
.309	.0752	.7696	.6198
.6273	.0533	.7203	.8251

B = $NaNO_3$; T = 298.1°K (162)

m_B	S_A	$\log(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.1008	0.1611	0.7929	0.5118
.3139	.179	.7472	.702
.622	.1994	.7003	.8675

B = Na_2SO_4; T = 298.1°K (162)

m_B	S_A	$\log(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0528	0.1633	0.7870	0.5672
.1605	.180	.7447	.814
.3305	.1951	.7002	1.089

B = KCl; T = 298.1°K (162)

m_B	S_A	$\log(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0983	0.1136	0.8093	0.4603
.2994	.0757	.7734	.6125
.6089	.0535	.7252	.8139

c_B	s_A	$\log(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
T = 298.1°K (1078)			
0.0	0.1481	0.8295	0.385
.04973	.1282	.8205	.4218
.09933	.1123	.8023	.460

B = KNO_3; T = 298.1°K (162)

m_B	S_A	$\log(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0971	0.1173	0.7995	0.4631
.2954	.0846	.7464	.6164
.6686	.0642	.6637	.856

B = K_2SO_4; T = 298.1°K (162)

m_B	S_A	$\log(1/m_\pm)$	$\mu^{\frac{1}{2}}$
0.0499	0.1194	0.7909	0.5187
.1517	.0857	.7385	.7354
.3004	.0644	.6840	.9826

c_B	s_A	$\log(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
T = 298.1°K (1078)			
0.02485	0.1315	0.8115	0.454
.04961	.1181	.7954	.516

$KBrO_3(s) = K^+ + BrO_3^-$

B = $NaCl$; T = 298.1°K (468)

c_B	s_A	$\log(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.4715	0.3265	0.6859
.5	.5220	.2923	1.011
1	.5616	.2505	1.25
2	.6042	.2188	1.614
3	.6244	.2045	1.904
4	.6400	.1938	2.154

B = $NaNO_3$; T = 298.1°K (468)

c_B	s_A	$\log(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.5	0.5745	0.2407	1.037
1	.6794	.1678	1.296
2	.768	.1146	1.664
3	.9026	.0444	1.976
4	1.031	−0.01326	2.243

$KIO_3(s) = K^+ + IO_3^-$

B = KOH; T = 293.1°K (201)

c_B	s_A	c_B	s_A
4.71	0.0390	11.10	0.0128
5.06	.0362	12.19	.0131
6.35	.0256	12.92	.0135
7.95	.0179	14.02	.0154
9.41	.0144	14.85	.0194
10.95	.0130		

$KMnO_4(s) = K^+ + MnO_4^-$

B = Na_2SO_4; T = 298.1°K (1456)

c_B	s_A	d_4^{25}
0.0	0.469	1.0454
.0655	.490	1.0554
.5535	.548	1.1180
1.691	.489	1.2363

B = KOH; T = 298.1°K (1456)

c_B	s_A	c_B	s_A
1.0	0.228	6.0	0.092
2.0	.153	8.0	.046
4.0	.102	10.0	.032

B = KCl; T = 298.1°K (1456)

c_B	s_A	c_B	s_A
0.1	0.4315	1.0	0.220
.5	.306	2.0	.1432

B = K_2SO_4; T = 298.1°K (1456)

c_B	s_A	d_4^{25}
0.0	0.469	1.0454
.048	.437	1.0483
.1195	.395	1.0537
.337	.307	1.0730
.486	.266	1.0876
.583	.247	1.0979

B = K_2CO_3; T = 298.1°K (1456)

c_B	s_A	c_B	s_A
0.05	0.4375	2.0	0.093
.5	.2589		

$2PbBr_2.KBr(s) = 2Pb^{++} + K^+ + 5Br^-$

B = KBr

m_B	$m_{(PbBr_2)}$	m_B	$m_{(PbBr_2)}$
T = 298.1°K (1192)			
0.3887	0.0070	0.8041	0.00740
.5902	.00707	1.200	.01137

c_B	$c_{(PbBr_2)}$	c_B	$c_{(PbBr_2)}$
T = 298.1°K (611)			
0.79	0.00725	3.23	0.08542
1.58	.00874	4.28	.1790
2.16	.02650		

$PbBr_2$ added to solution of concentration shown. Solid $2PbBr_2.KBr$ must have been present

$K[Co(NO_2)_2C_2O_4(NH_3)_2](s) = K^+ + [Co(NO_2)_2C_2O_4(NH_3)_2]^-$

B = KCl; T = 273.1°K (204)

c_B	s_A	$\log(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.1	0.00351	1.7199	0.321

B = KNO_3; T = 273.1°K (204)

c_B	s_A	$\log(1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.1	0.03800	1.7020	0.3215

$Cs[Co(NO_2)_4(NH_3)_2](s) = Cs^+ + [Co(NO_2)_4(NH_3)_2]^-$

B = $MgSO_4$; T = 273.1°K (204, 212)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.00532	2.2741	0.0730
.5	.00815	2.1888	1.417

B = $Mg(NO_3)_2$; T = 273.1°K (204, 212)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.5	0.01113	1.9535	1.230

B = NaCl; T = 293.1°K (204)

c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
0.0	0.01713	1.7664	0.1306
.1	.01987	1.7018	.3455

B = $NaNO_3$ (204, 212)

T, °K	c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
273.1	0.1	0.01268	1.8969	1.006
293.1	0.1	0.02055	1.6872	0.347

B = $NaCHO_2$, Formate (204, 212)

T, °K	c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
273.1	1.0	0.00785	2.1051	1.004

B = KCl (204)

T, °K	c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
293.1	0.1	0.020210	1.6944	0.3464

B = KNO_3 (204)

T, °K	c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
293.1	0.1	0.020920	1.6794	0.347

$Cs[Cr(CNS)_4(NH_3)_2](s) = Cs^+ + [Cr(CNS)_4(NH_3)_2]^-$

B = $MgSO_4$ (204, 212)

T, °K	c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
273.1	0.0	0.00789	3.1029	0.0289
273.1	.5	.00976	3.0105	1.414

B = $Mg(NO_3)_2$ (204, 212)

T, °K	c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
273.1	0.5	0.001356	2.8677	1.226

B = NaCl (204)

T, °K	c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
293.1	0.0	0.002629	2.5802	0.0512
293.1	.1	.003072	2.5126	.320

B = $NaNO_3$ (204, 212)

T, °K	c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
273.1	1.0	0.001365	2.8649	1.006
293.1	0.1	0.003182	2.4073	0.321

B = $NaCHO_2$, Formate (204, 212)

T, °K	c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
273.1	1.0	0.000831	3.0804	1.000

B = KCl (204)

T, °K	c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
293.1	0.1	0.003110	2.5072	0.321

B = KNO_3 (204)

T, °K	c_B	s_A	$\log (1/c_\pm)$	$\mu_c^{\frac{1}{2}}$
293.1	0.1	0.003233	2.4904	0.321

LITERATURE

(For a key to the periodicals see end of volume)·

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(10) Abel, *B13:* p. 1. (10.5) Abich, *13*, **26**: 314; 1831. (11) Åkerlöf, *1*, **48**: 1160; 26. (12) Allen and Lombard, *12*, **43**: 175; 17. (13) Allmand, *4*, **97**: 603; 10. (14) Allmand and Hunter, *83*, **24**: 300; 28. (15) Allmand and Polack, *4*, **115**: 1020; 19. (16) Allner, *397*, **48**: 1035, 1057, 1081, 1107; 05. (17) Allner, *Diss.*, Karlsruhe, 1905. (18) Andreae, *7*, **7**: 241; 91. (19) Andrew, *4*, **105**: 444; 14.

(20) Andrussov, *7*, **115**: 273; 25. (21) Andrussov, *7*, **116**: 81; 25. (22) Applebey and Reid, *4*, **121**: 2129; 22. (23) Arctowski, *93*, **8**: 314; 95. (24) Armstrong and Eyre, *5*, **88**: 234; 13. (25) Arndt and Schraube, *B13*: p. 46. (26) Arrhenius, *7*, **11**: 391; 93. (27) Askenasy and Klonowsky, *9*, **16**: 104; 10. (28) Askenasy and Solberg, *B13*: p. 53. (29) Atkins and Werner, *4*, **101**: 1167; 12.

(30) Atkinson; *cf.* (1184). (31) Atkinson, Heycock and Pope, *4*, **117**: 1410; 20. (32) Auerbach, *93*, **37**: 353; 03. (33) Auerbach, *9*, **10**: 161; 04. (34) Auerbach, *7*, **49**: 217; 04. (35) Auerbach and Pick, *291*, **38**: 243; 11. (36) Auerbach and Pick, *291*, **45**: 113; 13. (37) Babinski, *Diss.*, Leipzig, 1906. *See* (196, 470). (38) Badger, *1*, **46**: 2166; 24. (39) Bäckström, *7*, **97**: 179; 21.

(40) Bagdasarian, *78*, **51**: 449; 27. (41) Bagster, *4*, **111**: 494; 17. (42) Bahr, *93*, **71**: 79; 11. (43) Bahr and Sackur, *93*, **73**: 101; 11. (44) Baker, *4*, **65**: 615; 94. (45) Ballin, *Diss.*, Wurzburg, 1923. *See* (1025). (46) Balz, *Thesis*, Darmstadt, 1919. (47) Barnes, *50*, **4**: 339; 00. (48) Barnes, *62*, **199**: 149; 02. (49) Barnes, *Rep. Brit. Assoc.*, *Winnipeg*, 403; 09.

(50) Barnes and Lucas, *50*, **8**: 196, 04. (51) Barre, *34*, **150**: 1321; 10. (52) Barre, *34*, **150**: 1599; 10. (53) Barre, *6*, **24**: 145; 11. (54) Barre, *27*, **11**: 646; 12. (55) Barre, *34*, **156**: 1017; 13. (56) Bartlett, *1*, **49**: 65; 27. (57) Barus, *3*, **29**: 141; 90. (58) Bassarow, *42*, **1**: 283; 70. (59) Bassett and Taylor, *4*, **105**: 1926; 14.

(60) Bates and Kirschman, *1*, **41**: 1991; 19. (61) Baubigny, *34*, **146**: 1263; 08. *27*, **3**: 772; 08. (62) Baud, *6*, **1**: 8; 04. (63) Baur and Glaessner, *7*, **43**: 354; 03. (64) Baur and Orthner, *7*, **91**: 75; 16. (65) Baur and Voerman, *7*, **52**: 467; 05. (66) Baxter and Cooper, *1*, **46**: 923; 24. (67) Baxter, Hickey and Holmes, *1*, **29**: 127; 07. (68) Baxter and Lansing, *1*, **42**: 419; 20. (69) Baxter and Starkweather, *1*, **38**: 2038; 16.

(70) Baxter and Warren, *1*, **33**: 340; 11. (71) Beck, *9*, **17**: 843; 11. (72) Beck and Stegmüller, *291*, **34**: 446; 10. (73) Bell, *4*, **21**: 350; 68. (74) Bell and Taber, *50*, **11**: 637; 07. (75) Bellati and Lussana, *24*, **7**: 8; 89. (76) Bellati, Manfredo and Lussana, *24*, **7**: 1051; 89. (77) Benrath and Kohlberg, *93*, **138**: 65, 24. (78) Berger and Crut, *34*, **173**: 977; 21. (79) Bergius, *B13*: p. 68.

(80) Bergmann, *397*, **39**: 117; 96. (81) Bergstrom, *50*, **26**: 358; 22. (82) Bergstrom, *1*, **46**: 1559; 24. (83) Berl and Austerweil, *9*, **13**: 165; 07. (84) Berl and Samtleben, *92*, **35**: 201, 206; 22. *33*, **27**: 1025; 22. (85) Bernhardt, *63*, **26**: 265; 25. (86) Bernini, *63*, **7**: 168; 06. (87) Berthelot, *34*, **131**: 380; 00. (87.5) Berthelot, *B73*, **2**: 169; 97. (88) Bichowsky, *1*, **44**: 116; 22. (89) Bichowsky, *1*, **45**: 2225; 23.

(90) Biltz, *7*, **19**: 385; 96. (91) Biltz, *7*, **40**: 185; 02. (92) Biltz, *7*, **43**: 41; 03. (93) Biltz, *7*, **82**: 688; 13. (94) Biltz, *93*, **130**: 93; 23. (95) Biltz and Fetkenheuer, *93*, **83**: 163; 13. (96) Biltz and Fetkenheuer, *93*, **89**: 97; 14. (97) Biltz and Fetkenheuer, *93*, **89**: 134; 14. (98) Biltz and Fischer, *93*, **124**: 230; 22. (99) Biltz and Fischer, *93*, **129**: 1; 23.

(100) Biltz and Hansen, *93*, **127**: 1; 23. (101) Biltz and Hüttig, *93*, **109**: 89; 20. (102) Biltz and Hüttig, *93*, **109**: 111; 20. (103) Biltz and Hüttig, *93*, **114**: 241; 20. (103.5) Biltz and Hüttig, *93*, **119**: 115; 21. (104) Biltz and Messerknecht, *93*, **129**: 161; 23. (105) Biltz and Meyer, *7*, **4**: 262; 89. (106) Biltz and Meyer, *25*, **22**: 725; 89. (107) Biltz and Stollenwerk, *93*, **114**: 174; 20. (108) Biltz and Stollenwerk, *93*, **119**: 97; 21. (109) Bineau, *6*, **67**: 240; 38.

(110) Birge and Sponer, *2*, **28**: 259; 26. (111) Birner and Kuhne, *42*, **12**: 432; 14. (112) Biron, *53*, **31**: 171; 99. (113) Bissell and James, *1*, **38**: 873; 16. (114) Bjerrum, *7*, **59**: 336, 581; 07. (115) Bjerrum, *7*, **73**: 724; 10. (116) Bjerrum, *7*, **79**: 513; 12. (117) Bjerrum, *7*, **81**: 281; 12. (118) Bjerrum, *7*, **79**, 537; 12. (119) Bjerrum, *214*, **12**: No. 4; 15.

(120) Bjerrum, *93*, **119**: 179; 21. (121) Bjerrum, *7*, **106**: 230; 24. (122) Blanc, *42*, **18**: 28; 20. (123) Blarez, *34*, **112**: 434, 939, 1213; 11. (124) Blitz and Preuner, *7*, **39**: 323; 02. (125) Blum, *172 (8th)*, **1**: 75; 12. (126) Bodenstein, *7*, **29**: 295; 99. (127) Bodenstein, *9*, **14**: 544; 08. (128) Bodenstein, *136*, **32**: 539; 08. (129) Bodenstein, *136*, **36**: 606; 13.

(130) Bodenstein, *7*, **100**: 68; 21. (131) Bodenstein and Cramer, *9*, **22**: 327; 16. (132) Bodenstein and Dunant, *7*, **61**: 437; 07. (133) Bodenstein and Geiger, *7*, **49**: 70; 04. (134) Bodenstein and Katayama, *9*, **15**: 244; 09. *7*, **69**: 26; 09. (135) Bodenstein and Plant, *7*, **110**: 399; 24. (136) Bodenstein and Pöhl, *9*, **11**: 373; 05. (137) Bodenstein and Schubart, *9*, **23**: 105; 17. (138) Bodenstein and Suzuki, *9*, **16**: 912; 10. (139) Bodländer, *7*, **35**: 23; 00.

(140) Bodländer and Eberlein, *25*, **36**: 3945; 03. (141) Bodländer and Fittig, *7*, **39**: 597; 01. (142) Bodländer and Storbeck, *93*, **31**: 1; 02. (143) Bodländer and Storbeck, *93*, **31**: 458; 02. (144) Bogue, *1*, **42**: 2575; 20. (145) Bohr and Bock, *8*, **44**: 318; 91. (146) Boissieu, *27*, **47**: 494; 87. (147) Bokhorst, *Diss.*, Amsterdam, 1915. (148) Bolte, *7*, **80**: 338; 12. (149) Bondnikoff and Syrkine, *Bull. Inst. Polytech. Ivanovo Voaniesensk.*, **7**: No. 1, 84: 23.

(150) Bone and Coward, *4*, **97**: 1219; 10. (151) Bone and Jerdan, *4*, **71**: 41; 97. (152) Bone and Jerdan, *4*, **79**: 1042; 01. (153) Bonnefoi, *6*, **23**: 317; 01. (154) Bonnier, *14*, **5**: 37; 26. (155) Bonsdorff, *25*, **36**: 2322; 03. (156) Bonsdorff, *93*, **41**: 132; 04. (157) Born, *9*, **31**: 309; 25. (158) Bornemann and Hengatenberg, *187*, **17**: 339; 21. (159) Böttger, *7*, **46**: 521; 03.

(160) Boudouard, *34*, **130**: 132; 00. (161) Bouton, Riddell and Duschak, *30*, No. **317**; 24. (162) Bozorth, *1*, **45**: 2653; 24. (163) Braithwaite, *135*, **72**: 211; 95. (164) Branch, *1*, **37**: 2316; 15. (165) Braun, *7*, **33**: 721; 00. (166) Braune, *93*, **111**: 109; 20. (168) Braune and Koref, *93*, **87**: 175; 14. (169) Braune and Ramstetter, *7*, **102**: 480; 22.

(170) Brauner, *4*, **73**: 951; 98. (171) Bray, *1*, **32**: 932; 10. (172) Bray and Connolly, *1*, **33**: 1485; 11. (173) Bray and MacKay, *1*, **32**: 914; 10. (174) Bray and MacKay, *1*, **32**: 1207; 10. (175) Bray and Winninghoff, *1*, **33**: 1663; 11. (176) Bredig and Shirado, *9*, **33**: 209; 27. (177) Breitner,

Thesis, Budapest, 1911. (178) Bridgman, *1*, **36**: 1344; 14. (179) Briggs and Migrdichian, *50*, **28**: 1121; 24.

(180) Brill, *93*, **45**: 275; 05. (181) Brill, *8*, **21**: 170; 06. (182) Briner, *42*, **4**: 276; 06. (183) Briner, *42*, **13**: 18; 15. (184) Briner, *34*, **162**: 387; 16. (185) Briner and Kahn, *42*, **12**: 534; 14. Kahn, *Thesis*, Geneva, 1914. (186) Brislee, *83*, **4**: 159; 09. (187) Brönsted, *7*, **50**: 481; 04. (188) Brönsted, *7*, **56**: 645; 06. (189) Brönsted, *7*, **55**: 371; 06.

(190) Brönsted, *7*, **65**: 84; 09. (191) Brönsted, *7*, **65**: 744; 09. (192) Brönsted, *7*, **68**: 693; 10. (193) Brönsted, *7*, **77**: 129; 11. (194) Brönsted, *7*, **80**: 206; 12. (195) Brönsted, *9*, **18**: 714; 12. (196) Brönsted, *9*, **19**: 754; 13. (197) Brönsted, *7*, **88**: 479; 14. (198) Brönsted, *9*, **20**: 81; 14. (199) Brönsted, *137*, **2**: No. 10; 19.

(200) Brönsted, *147*, **5**: No. 25; 19. (201) Brönsted, *1*, **42**: 1448; 20. (202) Brönsted, *1*, **42**: 761; 20. (203) Brönsted, *4*, **119**: 574; 21. (204) Brönsted, *1*, **44**: 877; 22. (205) Brönsted, *1*, **44**: 938; 22. (206) Brönsted, *7*, **100**: 139; 22. (207) Brönsted, *1*, **45**: 2898; 23. (208) Brönsted and Brumbaugh, *1*, **48**: 2015; 26. (209) Brönsted and La Mer, *1*, **46**: 555; 24.

(210) Brönsted and Pedersen, *7*, **103**: 307; 22. (211) Brönsted and Pedersen, *137*, **1**: No. 3; 17. (212) Brönsted and Petersen, *1*, **43**: 2265; 21. (213) Browne and Houlehan, *1*, **35**: 649; 13. (214) Brühl, *25*, **28**: 2847; 95. (215) Bruner, *9*, **19**: 861; 13. (216) Bubnoff, *7*, **88**: 641; 14. (217) Budde, *93*, **78**: 169; 12. (218) Buehrer, *Unpubl. Thesis*, Univ. of Calif., Berkeley, Calif., 1921. (219) Buehrer and Roseveare, *1*, **49**: 1989; 27.

(220) Buehrer, Wartman and Nugent, *1*, **49**: 1271; 27. (221) Bugarszky, *7*, **71**: 705; 10. (222) Bunsen, *8*, **141**: 1; 70. (223) Burdick and Freed, *1*, **43**: 518; 21. (224) *365*, No. **29**; 10. (225) *365*, No. **35**; 19. (226) Burgstaller, *Abh. Lotos*, **3**: 83; 12. (227) Burrell and Robertson, *1*, **37**: 2482; 15. (228) Burrows, *1*, **46**: 1623; 24. (229) Burrows and Fawsitt, *4*, **105**: 609; 14.

(230) Burrows and Lucarini, *1*, **49**: 1157; 27. (231) Butler and Hiscocks, *4*, **1926**: 2554. (232) Cahours, *13*, **141**: 39; 67. (233) Cailletet and Bordet, *34*, **95**: 58; 82. (234) Cailletet, Colardeau and Rivière, *34*, **130**: 1585; 00. (235) Callender and Barnes, *5*, **62**: 117; 97. (236) Calvert, *7*, **38**: 513; 01. (237) Cameron, *50*, **5**: 556; 01. (238) Cameron, *50*, **11**: 641; 07. (239) Cameron and Bell, *50*, **10**: 210; 06.

(240) Cameron and Bell, *1*, **28**: 1220; 06. (241) Cameron, Bell and Robinson, *50*, **11**: 396; 07. (242) Cameron and Breazeale, *50*, **8**: 335; 04. (243) Cameron and Brown, *50*, **9**: 210; 05. (243.5) Cameron and Patten, *50*, **15**: 67; 11. (244) Cameron and Robinson, *50*, **11**: 577, 690; 07. (245) Cameron and Robinson, *50*, **11**: 273; 07. (246) Cameron and Seidell, *50*, **5**: 643; 01. (247) Cameron and Seidell, *50*, **7**: 578, 588; 03. (249) Campbell, *Diss.*, Breslau, 1906. *See* (2).

(250) Campbell, *135*, **96**: 15, 25; 07. (251) Campbell, *83*, **3**: 24; 07. (252) Cantelo, *50*, **28**: 1036; 24. (253) Cantoni and Jolkowski, *27*, **1**: 1181; 07. (254) Cantoni and Mauri, *27*, **3**: 929; 08. (255) Carbonelli, *36*, **49 I**: 151; 19. (256) Carmody, Stanford University, Calif., and Reed College, Portland, Oregon, *0*. (257) Carpenter and Jette, *1*, **45**: 578; 23. (258) Carpenter and Smith, *140*, **98**: 139; 18. (259) Carson, *1*, **29**: 499; 09.

(260) Carter, *4*, **127**: 2861; 25. (261) Carter, Lea and Robinson, *4*, **131**: 1906; 27. (262) Casselmann, *13*, **83**: 257; 52. (263) Cavazzi, *36*, **46 II**: 122; 16. (264) Caven and Ferguson, *4*, **121**: 1406; 22. (265) Caven and Ferguson, *4*, **125**: 1307; 24. (266) Caven and Sand, *4*, **99**: 1359; 11. (267) Caven and Sand, *4*, **105**: 2752; 14. (268) Centnerszwer, *7*, **85**: 99; 13. (269) Centnerszwer and Andrusow, *7*, **111**: 79; 24.

(270) Centnerszwer and Bružs, *7*, **114**: 237; 25. (271) Centnerszwer and Bružs, *7*, **115**: 365; 25. (272) Centnerszwer and Bružs, *Acta Univ. Latviensis*, **14**: 485; 26. (273) Centnerszwer and Bružs, *Ibid.*, **14**: 505; 26. (274) Centnerszwer, Falk and Awerbach, *7*, **115**: 29; 25. (275) Centnerszwer and Krustinsons, *7*, **132**: 185; 28. (276) Chaudron, *34*, **159**: 237; 14. (277) Chaudron, *14*, **16**: 221; 21. (278) Chauvenet, *6*, **23**: 275; 11. (279) Ming Chow, *1*, **42**: 488; 20.

(280) Christiansen, *7*, **103**: 99; 23. (281) Claude, *34*, **169**: 1039; 19. (282) Claus, *13*, **59**: 234; 46. (283) Clement, *29*, No. **17**: 11. (284) Clement and Adams, *29*, No. **7**; 09. (285) Cleve, *93*, **32**: 129; 02. (286) Clouet, *14*, **11**: 30; 1791. (287) Coehn and Stuckardt, *7*, **91**: 722;16. (288) Cofetti and Forester, *25*, **38**: 2934; 05. (289) Cohen, *7*, **18**: 61; 95.

(290) Cohen, *7*, **30**: 623; 99. (291) Cohen, *7*, **33**: 57; 00. (292) Cohen, *7*, **35**: 588; 00. (293) Cohen, *7*, **36**: 517; 01. (294) Cohen, *7*, **48**: 243; 04. (295) Cohen, *18*, **5**: 195; 00. (297) Cohen, Chattaway and Tombrook, *7*, **60**: 706; 07. (298) Cohen and von Eyk, *7*, **30**: 601; 99. (299) Cohen, Inouye and Euwen, *7*, **75**: 1; 10.

(300) Cohen and Moesveld, *7*, **115**: 151; 25. (301) Colani, *34*, **156**: 1075; 13. (302) Collenberg, *7*, **109**: 353; 24. (303) Collins and Wood, *4*, **121**: 441; 22. (304) Colson, *34*, **128**: 1458; 99. (305) Colson, *34*, **132**: 467; 01. (306) Colson, *34*, **140**: 865; 05. (307) Colson, *34*, **148**: 837; 09. (308) Colson, *34*, **154**: 428; 12. (309) Condon, *197*, **13**: 466; 27.

(310) Coward and Wilson, *4*, **115**: 1380; 19. (311) Cragoe, Meyers and Taylor, *1*, **42**: 206; 20. (312) Creighton and Githens, *143*, **179**: 161; 15. (313) Creighton and Ward, *1*, **37**: 2333; 15. (314) Crut, *Thesis*, Paris, 1923. (315) Cundall, *4*, **59**: 1076; 91. (316) Cundall, *4*, **67**: 794; 95. (317) Dalton, Pomeroy and Weymouth, *1*, **46**: 60; 24. (318) d'Anselme, *27*, **29**: 936: 03. (319) Danneel, *7*, **33**: 415; 00.

(320) Davies, *5*, **78**: 41; 06. (321) Davis, *4*, **95**: 1397; 09. (322) Dawson and Leslie, *4*, **99**: 1601; 11. (322.5) Day and White, Geophysical Laboratory, Washington, D. C., *0*. (323) Debray and Joly, *34*, **106**: 100; 88. (324) Debray and Joly, *34*, **106**: 328; 88. (325) Deckert, *Diss.*, Rostock, 1924. (326) Demassieux, *14*, **20**: 233; 23. (327) Demassieux, *34*, **177**: 51; 23. (328) Denham, *4*, **93**: 41; 08. (329) Denham, *7*, **72**: 641; 10.

(330) Derby, Daniels and Gutsche, *1*, **36**: 793; 14. (331) Derby and Yngve, *1*, **38**: 1439; 16. (332) Deville, *34*, **70**: 1105, 1201; 70. (333) Deville, *34*, **71**: 30; 71. (334) DeVries and Rodebush, *1*, **49**: 656; 27. (335) Dewar, *5*, **89**: 158; 13. (336) de Wijs, *Thesis*, Delft, 1923. (337) Dhar and Datta, *9*, **19**: 407; 13. (338) Ditte, *Thesis*, Paris, 1870. (339) Ditte, *25*, **9**: 1130, 1432; 76.

(340) Ditte, *34*, **83**: 56, 223; 76. (341) Ditte, *34*, **92**: 718; 81. (342) Ditz and Kanhäuser, *93*, **98**: 128; 16. (343) Dixon, Campbell and Parker, *5*, **100**: 1; 21. (344) Dixon and Greenwood, *5*, **105**: 199; 24. (344.5) Dobler, *7*, **101**: 1; 22. (345) Dodd, *1*, **42**: 1579; 20. (346) Doerinckel and Werner, *93*, **115**: 1; 20. (347) Dolezalek, *9*, **4**: 349; 98. (348) Domke and Bein, *93*, **43**: 125; 04. (349) Donnan and Thomas, *4*, **99**: 1788; 11.

(350) Doolan and Partington, *83*, **20**: 342; 24. (351) Dougherty and Taylor, *50*, **27**: 533; 23. (352) Dover, *Diss.*, Breslau, 1908. (353) Dragert, *Diss.*, Berlin, 1914. (354) Drucker, *93*, **28**: 361; 01. (355) Drucker, *7*, **49**: 563; 04. (356) Drucker, *9*, **17**: 398; 11. (357) Dunn, *135*, **43**: 121; 81. (358) Dunn, *135*, **45**: 270; 82. (359) Dunningham, *4*, **105**: 368; 14.

(360) Eastman, *1*, **44**: 975; 22. (361) Eastman and Evans, *1*, **46**: 888; 24. (362) Eastman and Robinson, *1*, **50**: 1106; 28. (363) Eastman and Rodebush, *1*, **40**: 489; 18. (364) Eastman and Sullivan, U. S. Bureau of Mines Experiment Station, Berkeley, Calif., *0*. (365) Eastman, Williams and Young, *1*, **46**: 1184; 24. (366) Edgar, *Thesis*, Mass. Inst. Tech., Boston, 1912. (367) Edgar and Cannon, *1*, **44**: 2842; 22. (368) Egerton, *3*, **33**: 33; 17. (369) Egerton, *5*, **103**: 469; 23.

(370) Ehrenberg and Bahr, *J. Landwirtschaft*, **61**: 427; 23. (371) Ehlert and Hempel, *9*, **18**: 727; 12. (372) Ellis, *1*, **38**: 737; 16. (373) Emich, *57*, **26**: 1011; 05. (373.5) von Ende, *93*, **26**: 129; 01. (374) Engel, *6*, **13**: 344; 88. (375) Engel, *6*, **17**: 338; 89. (376) Engel and Ville, *34*, **93**: 340; 81. (377) Engels, *397*, **62**: 477, 493; 19. (377.5) Enklaar, *176*, **9**: 28;12. (378) Ephraim, *25*, **45**: 1322; 12. (379) Ephraim, *7*, **81**: 513; 13.

(380) Ephraim, *7*, **83**: 196; 13. (381) Ephraim, *25*, **46**: 3103; 13. (382) Ephraim, *25*, **50**: 1069; 17. (383) Ephraim, *25*, **51**: 644; 18. (384) Ephraim, *25*, **51**: 706; 18. (385) Ephraim, *25*, **52**: 236; 19. (386) Ephraim, *25*, **52**: 241; 19. (387) Ephraim, *25*, **52**: 940; 19. (388) Ephraim, *25*, **52**: 957; 19. (389) Ephraim and Aellig, *37*, **6**: 37; 23.

(390) Ephraim and Bolle, *25*, **48**: 638; 15. **48**: 1770; 15. (391) Ephraim and Jahnsen, *25*, **48**: 41; 15. (392) Ephraim and Kornblum, *25*, **49**: 2007; 16. (393) Ephraim and Linn, *25*, **46**: 3742; 13. (394) Ephraim and Michel, *37*, **4**: 900; 21. (395) Ephraim and Millmann, *25*, **50**: 529; 17. (396) Ephraim and Moser, *25*, **53**: 548; 20. (397) Ephraim and Muller, *25*, **54**: 973; 21. (398) Ephraim and Rosenberg, *25*, **51**: 130; 18. (399) Ephraim and Wagner, *25*, **50**: 1088; 17.

(400) Eucken, *7*, **107**: 436; 23. (401) Eucken and Fried, *96*, **29**: 36; 24. (402) Eucken and Karwat, *7*, **112**: 467; 24. (403) Eucken, Karwat and Fried, *96*, **29**: 1; 24. (403.5) von Euler, *25*, **36**: 2878, 3400; 03. (404) Ewald, *8*, **44**: 1213; 14. (405) Falcke, *25*, **46**: 743; 13. (406) Falcke, *9*, **21**: 37; 15. (407) Falcke, *9*, **22**: 121; 16. (408) Falcke, *9*, **27**: 268; 21. (408.1) von Falkenstein, *7*, **59**: 313; 07. (408.2) von Falkenstein, *7*, **68**: 270; 09. (408.3) von Falkenstein, *7*, **65**: 371; 09. (409) Faurholt, *214*, **20**: No. 3; 21.

(410) Favre and Silbermann, *6*, **37**: 406; 52. (411) Fawsitt, *7*, **41**: 601; 02. (412) Fay and North, *11*, **25**: 216; 01. (413) Fedotieff, *93*, **69**: 22; 10. (414) Ferguson, *1*, **40**: 1626, 1900; 18. (415) Ferguson, *128*, **13**: 275; 23. (416) Ferguson and Manning, *45*, **11**: 946; 19. (417) Fichter and Spengel, *93*, **82**: 192; 13. (418) Fichter, Steiger and Stanisch, *Verh. Naturf. Ges., Basel*, **28 II**: 66; 17. (419) Finckh, *93*, **45**: 116; 05.

(420) Findlay, *7*, **34**: 409; 00. (421) Findlay, *4*, **85**: 403; 04. (422) Findlay and Shen, *4*, **101**: 1459; 12. (423) Finkelstein, *25*, **39**: 1585; 06. (424) Fischer, *93*, **78**: 41; 12. (425) Fischer and Brachmer, *25*, **39**: 940; 06. (426) Fixed Nitrogen Research Laboratory, Washington, *Report on Fixation and Utilization of Nitrogen*, p. 218; 1922. (427) Folger and Rodebush, *1*, **45**: 2080; 23. (428) Fonda and Van Aernem, *45*, **14**: 539; 22. (429) Foote, *7*, **33**: 740; 00.

(430) Foote and Scholes, *1*, **33**: 1309; 11. (431) Foote and Smith, *1*, **30**: 1344; 08. (432) Forbes, *1*, **33**: 1937; 11. (433) Forbes and Cole, *1*, **43**: 2492; 21. (434) de Forcrand, *34*, **94**: 967; 82. (435) de Forcrand, *34*, **130**: 1308, 1388; 00. (436) de Forcrand, *34*, **176**: 355; 23. (437) de Forcrand and Fonzes-Diaçon, *6*, **26**: 247; 02. (438) de Forcrand and Fonzes-Diaçon, *34*, **134**: 229; 02. (439) de Forcrand and Taboury, *34*, **169**: 162; 19.

(440) de Forcrand and Villard, *34*, **106**: 849, 1357; 88. (441) Formanek, *185*, **18**: 270; 87. (442) Fowler, *4*, **79**: 285; 01. (443) Fox, *4*, **95**: 878; 09. (444) Fraenkel, *9*, **19**: 362; 13. (445) Franklin and Kraus, *50*, **11**: 553; 07. (446) Fraps, *11*, **27**: 288; 01. (447) Frary and Nietz, *1*, **37**: 2268; 15. (448) Free, *1*, **30**: 1366; 08. (449) Freeman, *324*, **6**: 129; 22. (449.5) Fricke, *7*, **113**: 248; 24.

(450) Fried, *7*, **123**: 406; 26. (451) Friedheim and Brühl, *91*, **38**: 690; 99. (452) Friedrich, *192*, **4**: 479; 07. (453) Friedrich, *77*, **31**: 1909; 11. (454)

Friedrich, *189*, **1912**; 653. (455) Friedrich and Blickle, *192*, **7**: 323; 10. (456) Friedrich and Leroux, *192*, **2**: 536; 05. (457) Friend, *140*, **80**: 172; 09. (458) Frowein, *7*, **1**: 5; 87. (459) Fulton, *80*, **60**: 280; 19.

(460) Fürth, *9*, **28**: 57; 22. (461) Garner and Matsumo, *4*, **119**: 1903; 21. (462) Garner and Matsumo, *4*, **121**: 1729; 22. (463) Gaudechon, *34*, **150**: 467; 10. (464) Gaus, *93*, **25**: 236; 00. (465) Gautier and Clausmann, *34*, **151**: 16, 355; 11. (466) Gebhardt, *Diss.*, Erlangen, 1904. (467) Gebhardt, *88*, **7**: 184; 05. (468) Geffcken, *7*, **49**: 257; 04. (469) Geffcken, *93*, **43**: 197; 05.

(470) Gerke, *1*, **44**: 1684; 22. (471) Gerke, *286*, **1**: 377; 25. (472) Gerke and Geddes, *50*, **31**: 886; 27. (473) Gerke and Gordon, *0*; *see* (471). (474) Gerke and Rourke, *1*, **49**: 1855; 27. (475) Germs, *176*, **14**: 1156; 17. (476) Gerth, *9*, **27**: 287; 21. (477) Getman, *1*, **38**: 792; 16. (478) Getman, *1*, **40**: 611; 18. (479) Getman, *50*, **32**: 91; 28.

(480) Getman, *50*, **32**: 940; 28. (481) Giacomini, *3*, **50**: 146; 25. (481.5) Giauque and Johnston, Univ. of Calif., Berkeley, Calif., *0*. (482) Gibson, *Diss.*, Breslau, 1911. (483) Gibson and Heitler, *96*, **49**: 465; 28. (484) Gibson, Latimer and Parks, *1*, **42**: 1533; 20. (485) Gibson, Latimer and Parks, *1*, **42**: 1542; 20. (486) Gillespie, *197*, **11**: 73; 25. (487) Gillespie, *285*, **4**: 84; 25. (488) Gillespie, *1*, **48**: 28; 26. (489) Gillespie and Hall, *1*, **48**: 1207; 26.

(490) Girardet, *27*, **7**: 1028; 10. (491) Glaser, *93*, **36**: 1; 03. (492) Glaser, *192*, **1**: 103, 121; 04. (493) Glass and Fuoss, *1*, **47**: 2892; 25. (494) Glasstone, *4*, **119**: 1689; 21. (495) Glasstone, *4*, **121**: 58; 22. (496) Glasstone, *4*, **121**: 1456; 22. (497) Glasstone, *4*, **121**: 1469; 22. (498) Głowczynski, *287*, **6**: 147; 14. (499) Goerges and Stähler, *25*, **42**: 3200; 09.

(500) Goldschmidt, *63*, **4**: 166; 02. (501) Goldschmidt, *96*, **20**: 159; 23. (502) Goldschmidt and Larsen, *7*, **71**: 437; 10. (503) Goldschmidt and Sunde, *7*, **56**: 1; 06. (504) Goldschmidt and Syngros, *93*, **5**: 129; 94. (504.5) Gooch and Austin, *93*, **17**: 264; 98. (505) Goodwin, *7*, **13**: 577; 94. (506) Goodwin and Kalmus, *2*, **28**: 1; 09. (507) Granger, *6*, **14**: 5; 98. (508) Grant and James, *1*, **39**: 933; 17. (509) Grau and Russ, *9*, **13**: 573; 07.

(510) Greenwood, *5*, **82**, 396; 09. (511) Greenwood, *5*, **83**: 483; 10. (512) Greenwood, *83*, **7**: 145, 11. (513) Greenwood, *9*, **18**: 319; 12. (514) Griffiths, *5*, **89**: 561; 14. (515) Griffiths and Griffiths, *5*, **88**: 549; 13. *62*, **213**: 119; 13. (516) Gróh, *7*, **81**: 695; 13. (516.5) von Groningen, *Diss.*, Delft, 1921. (517) Grotrian and Runge, *63*, **15**: 545; 14. (518) Grube, *9*, **30**: 517; 24. (519) Grube and Feucht, *9*, **28**: 568; 22.

(520) Grube and Hermann, *9*, **26**: 291; 20. (521) Grube and Huberich, *9*, **29**: 8; 23. (522) Grube and Krueger, *7*, **86**: 64; 14. (523) Grube and Metzger, *9*, **29**: 17; 23. (524) Grube and Schweigardt, *9*, **29**: 257; 23. (525) Grünberg, *93*, **80**: 337; 13. (526) Güntelberg, *61*, **1915**; 241. (527) Güntelberg, *7*, **123**: 199; 26. (528) Gunst and Bassett, *34*, **140**: 863; 05. (529) Gunther, *8*, **51**: 828; 16.

(530) Gunther, *9*, **23**: 197; 17. (531) Guntz, *34*, **128**: 996; 99. (532) Gutbier, Leuchs, Wiessmann and Maisch, *93*, **96**: 182; 16. (533) Gutbier and Ransohoff, *93*, **45**: 243; 05. (534) Gutmann, *13*, **299**: 267; 98. (535) Haber, *7*, **68**: 726; 09. (536) Haber, *9*, **16**: 244; 10. (537) Haber, *9*, **20**: 597; 14. (538) Haber, *92*, **27**: 475; 14. (539) Haber, Tamaru and Ponnaz, *9*, **21**: 89; 15.

(540) Haber and Maschke, *9*, **21**: 128; 15. (541) Haber and Tamaru, *9*, **21**: 191; 15. (542) Haber, Tamaru and Oeholm, *9*, **21**: 206; 15. (543) Haber and Tamaru, *9*, **21**: 228; 15. (544) Haber and Greenwood, *9*, **21**: 241; 15. (545) Haber and Fleischmann, *93*, **52**: 127; 07. (546) Haber and Fleischmann, *93*, **51**; 245; 06. (547) Haber and Fleischmann, *93*, **51**: 336; 06. (548) Haber and Foster, *93*, **51**: 289; 06. (549) Haber and Kerschbaum, *9*, **20**: 296; 14.

(550) Haber and Koenig, *9*, **13**: 725; 07. (551) Haber and Koenig, *9*, **14**: 689; 08. (552) Haber and Le Rossignol, *25*, **40**: 2144; 07. (553) Haber and Le Rossignol, *9*, **14**: 181; 08. (554) Haber and Le Rossignol, *9*, **14**: 513, 688; 08. (555) Haber and Moser, *9*, **11**: 598; 05. (556) Haber and van Oordt, *93*, **43**: 111; 05. (557) Haber and van Oordt, *93*, **44**: 341; 05. (558) Haber and van Oordt, *93*, **47**: 42; 05. (559) Haber and Richardt, *93*, **38**: 5; 04.

(560) Haber and Zisch, *96*, **9**: 302; 22. (561) Hackspill, *34*, **154**: 877; 12. (562) Hackspill, *6*, **27**: 613; 13. (563) Haehnel, *52*, **107**: 165; 24. (564) Haehnel, *52*, **108**: 187; 24. (565) Haehnel, *52*, **108**: 61; 24. (566) Hahn, *7*, **44**: 513; 03. (567) Hahn, *7*, **48**: 735; 04. (568) Halla, *9*, **30**: 124; 24. (569) Hampton, *50*, **30**: 980; 26.

(570) Harkins, *1*, **33**: 1807; 11. (571) Harkins and Paine, *1*, **41**: 1155; 19. (572) Harkins and Pearce, *1*, **38**: 2679; 16. (573) Harkins and Winninghoff, *1*, **33**: 1827; 11. (574) Harman, *50*, **31**: 616; 27. (575) Harman and Worley, *83*, **20**: 502; 25. (576) Harned, *1*, **37**: 2460; 15. (577) Harned, *1*, **38**: 1986; 16. (578) Harned, *1*, **42**: 1808; 20. (579) Harned, *1*, **48**: 326; 26.

(580) Harned and Åkerlöf, *63*, **27**: 411; 26. (581) Harned and Brumbaugh, *1*, **44**: 2729; 22. (582) Harned and Fleysher, *1*, **47**: 82; 25. (583) Harned and Sturgis, *1*, **47**: 945; 25. (584) Harned and Swindells, *1*, **48**: 126; 26. (585) Harries, *397*, **37**: 82; 94. (586) Harteck, *7*, **134**: 1; 28. (587) Hartley and Campbell, *4*, **93**: 741; 08. (588) Haslam, *45*, **16**: 782; 24. (589) Haslam, Calingaert and Taylor, *1*, **46**: 308; 24.

(590) Haslam and Forrest, *Gas Age-Record*, **52**: 615; 23. (591) Hauser and Wirth, *91*, **47**: 389; 08. (592) Hauser and Wirth, *92*, **22**: 484; 09. (593) Hauser and Wirth, *52*, **79**: 358; 09. (594) Hauser and Wirth, *93*, **78**: 75; 12. (595) Hedvall, *93*, **98**: 47; 16. (596) Heike, *93*, **118**: 254; 21. (597) Hellwig, *93*, **25**: 157; 00. (597.5) Hempel and Schubert, *9*, **18**: 729; 12. Hempel, *Diss.*, Dresden, 1912. (598) Henderson and Stegeman, *1*, **40**: 84; 18. (599) Henderson and Taylor, *50*, **20**: 663; 16.

(600) Henglein, *96*, **12**: 245; 22. (601) Henglein, *93*, **123**: 137; 22. (602) Henglein and Krüger, *93*, **130**: 181; 23. (603) Henglein, Rosenberg and Muchlinski, *96*, **11**: 1; 22. (604) Henning, *8*, **43**: 282; 14. (605) Herz, *B13*, **2**: 193; 12. (606) Herz, *93*, **94**: 1; 16. (607) Herz, *93*, **30**: 280; 02. (608) Herz, *93*, **66**: 358; 10. (609) Herz, *93*, **71**: 206; 11.

(610) Herz, *93*, **72**: 106; 11. (611) Herz and Hellebrandt, *93*, **130**: 188; 23. (612) Herz and Muhs, *25*, **36**: 3715; 03. (613) Herz and Muhs, *93*, **38**: 138; 03. (614) Herzfeld and Stiepel, *Rübenzuckerindustrie*, **1898**; 830. (615) Hevesy and Paneth, *93*, **82**: 323; 12. (616) Heycock and Lamplough, *182*, **28**: 3; 12. (617) Heycock and Lamplough, *135*, **105**: 66; 12. (618) Heycock and Neville, *4*, **72**: 383; 97. (618.5) Kohlrausch and Heydweiller, *see* Heydweiller, *8*, **28**: 503; 09. (619) Heyn, *93*, **39**: 1; 04.

(620) Hightower and White, *45*, **20**: 10; 28. (621) Hildebrand, *1*, **34**: 246; 12. (622) Hildebrand, *1*, **40**: 45; 18. (623) Hildebrand and Eastman, *1*, **37**: 2452; 15. (624) Hill, *1*, **30**: 68; 08. (625) Hill, *1*, **32**: 1186; 10. (626) Hill, *1*, **39**: 218; 17. (627) Hill, *1*, **43**: 254; 21. (628) Hill, *2*, **20**: 259; 22. (629) Hill and Simmons, *7*, **67**: 594; 09.

(630) Hill and Simmons, *1*, **31**: 821; 09. (631) Hiller, *7*, **81**: 591; 13. (632) Hilpert and Dieckmann, *25*, **48**: 1281; 15. (633) Hirsch, *Thesis*, Budapest. (634) Hirschkind, *93*, **67**: 113; 10. (634.5) van't Hoff, Armstrong, Hinrichsen, Weigert and Just, *7*, **45**: 257; 08. (635) Hoffman and Langebeck, *7*, **51**: 385; 05. (636) Hofman and Wanjukow, *80*, **43**: 523; 12. (637) Hogness and Lunn, *2*, **27**: 642; 26. (638) Hogness and Lunn, *2*, **27**: 732; 26. (639) Hoitsema, *7*, **17**: 1; 95.

(640) Holland, *9*, **18**: 234; 13. *See* (1059). (641) Hollmann, *7*, **37**: 193; 01. (642) Holmberg, *93*, **53**: 83; 07. (643) Holt, *3*, **13**: 630; 07. (644) Holt, Edgar and Firth, *7*, **82**: 513; 13. (645) Horak, *Diss.*, Berlin, 1909. (646) Horn, *11*, **37**: 619; 07. (647) Horn, *Trans. Wagner Free Inst. of Science*, **10**: 63; 23. (648) Horsch, *1*, **41**: 1787; 19. (649) Horstmann, *25*, **2**: 137; 69.

(650) Horstmann, *25*, **9**: 749; 76. (651) Horstmann, *13*, **187**: 48; 77. (652) Hüttig, *93*, **114**: 161; 20. (653) Hüttig, *93*, **123**: 31; 22. (654) Hüttig, *93*, **124**: 322; 22. (655) Hüttig and Kurre, *93*, **122**: 44; 22. (655.5) Hüttig and Kurre, *93*, **126**: 167; 23. (656) Hüttig and Martin, *93*, **125**: 269; 22. (657) Hüttig and Pohle, *93*, **138**: 1; 24. (658) Hüttig and Reuscher, *93*, **137**: 155; 24. (659) Hüttig and von Schroder, *93*, **121**: 243; 22.

(660) Hulett, *7*, **37**: 385; 01. (661) Hulett, *78*, **7**: 333; 05. (662) Hulett, *78*, **15**: 435; 09. (663) Iitaka, *159*, **8**: 99; 19. (663.5) Iitaka, *47*, **26**: 505; 12. (664) Ingold, *4*, **121**: 2419; 22. (665) Ingold and Wilson, *4*, **121**: 2278; 22. (666) Isambert, *Thesis*, Paris(?), 1868. (667) Isambert, *34*, **70**: 456; 70. (667.5) Isambert, *34*, **86**: 332; 78. (668) Isambert, *34*, **86**: 481; 78. (669) Isambert, *34*, **91**: 768; 80.

(670) Isambert, *34*, **92**: 919; 81. (671) Isambert, *34*, **93**: 731; 81. (672) Isambert, *34*, **96**: 340; 82. (673) Isambert, *34*, **97**: 1212; 83. (674) Ishikawa and Shibata, *41*, **48**: 59; 27. (675) Isnardi, *8*, **61**: 264; 20. (675.5) van Iterson-Rotgans, *7*, **87**: 305; 14. (676) Jackson, *4*, **99**: 1066; 11. (677) Jacques, *83*, **5**: 225; 08. (678) Jacob, *Diss.*, Breslau, 1924. (678.5) Jacobs, *176*, **14**: 208; 17. (679) Jaeger, *93*, **27**: 22; 01.

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(690) Jakowkin, *7*, **18**: 585; 95. (691) Jakowkin, *7*, **20**: 19; 96. (692) Jakowkin, *7*, **29**: 613; 99. (693) James and Holden, *1*, **35**: 559; 13. (694) James and Robinson, *1*, **35**: 754; 13. (695) Janneck and Meyer, *25*, **46**: 2876; 13. (695.5) Janneck and Meyer, *93*, **83**: 51; 13. (696) Jarry, *6*, **17**: 327; 99. (697) Jellinek, *93*, **49**: 229; 06. (698) Jellinek, *7*, **76**: 257; 11. (699) Jellinek and Czerwinski, *7*, **102**: 438; 22.

(700) Jellinek and Diethelm, *93*, **124**: 203; 22. (701) Jellinek and Gordon, *7*, **112**: 207; 24. (702) Jellinek and Winogradoff, *9*, **30**: 477; 24. (703) Jirsa and Jelinek, *9*, **30**: 286; 24. (704) Jirsa and Jelinek, *9*, **30**: 534; 24. (705) Jirsa and Jelinek, *Chem. Listy*, **18**: 1; 24. (706) Joannis, *6*, **7**: 5; 06. (707) Joannis and Croizier, *34*, **118**: 1149; 94. (708) Job, *34*, **176**: 1805; 23. (709) Job, *34*, **176**: 442; 23.

(710) Johnson, *135*, **54**: 75; 86. (711) Johnson, *7*, **61**: 457; 08. (712) Johnson, *7*, **65**: 36; 09. (713) Johnson, *1*, **33**: 777; 11. (714) Johnson, *1*, **34**: 877; 12. (715) Johnson and McIntosh, *1*, **31**: 1138; 09. (716) Johnston, *25*, **37**: 3625; 04. (717) Johnston, *7*, **62**: 330; 08. (718) Johnston, *1*, **32**: 938; 10. (719) Johnston, *1*, **37**: 2001; 15.

(720) Johnston, *1*, **38**: 947; 16. (721) Johnston, *45*, **9**: 873; 17. (722) Jolibois, *Thesis*, Paris, 1910. (723) Jolibois, *34*, **149**: 287; 09. (724) Jolibois, *34*, **151**: 382; 10. (725) Jones, *4*, **99**: 392; 11. (726) Jones, *4*, **105**: 2310; 14. (727) Jones and Hartmann, *1*, **37**: 752; 15. (728) Jones and Hartmann, *1*, **37**: 241; 15. (729) Jones and Hartmann, *78*, **30**: 295; 16.

(730) Jones and Kaplan, *1*, **50**: 1845; 28. (731) Jones and Kaplan, *1*, **50**: 2066; 28. (732) Jones and Schumb, *65*, **56**: 199; 21. (733) Jonker, *176*,

6: 1035; 09. (734) Joseph and Jinendradasa, *4*, **99**: 274; 11. (734.5) Joseph and Jinendradasa, *182*, **26**: 233; 11. (735) Jost, *9*, **14**: 373; 08. (736) Jost, *93*, **57**: 414; 08. (737) Joulin, *6*, **30**: 248; 73. (738) Joulin, *6*, **30**: 276; 73. (739) Jouniaux, *34*, **129**: 883; 99.

(740) Jouniaux, *34*, **132**: 1270; 01. (741) Jouniaux, *34*, **133**: 228; 01. (742) Jouniaux, *34*, **136**: 1003; 03. (743) Joyner, *93*, **77**: 103; 12. (744) Just, *7*, **37**: 342; 01. (745) Kameyama, *78*, **40**: 131; 21. (745.5) Kamiensky, *Bull. intern. acad. Polonaise*, **1926A**; 109. (746) Karwat, *7*, **112**: 486; 24. (747) Kasarnowsky, *Thesis*, Zürich, 1915. (748) Kasarnowsky, *93*, **128**: 17; 23. (749) Kasarnowsky, *93*, **128**: 33; 23.

(750) Kasarnowsky, *7*, **109**, 287; 24. (751) Katz, *202*, **95**: 16; 15. (752) Kendall, *3*, **23**: 958; 12. (753) Kendall, *147*, **2**: No. 38; 13. (754) Kendall, *1*, **38**: 1480; 16. (754.5) Kendall and Andrew, *1*, **43**: 1545; 21. (755) Kendall and Fuchs, *1*, **43**: 2017; 21. (756) Kendall and Fuchs, *1*, **44**: 1447; 22. (757) Kernot, d'Agostino and Pellegrino, *36*, **38 I**: 532; 08. (758) Kernot and Pomilio, *71*, **17**: 353; 12. (759) Keyes, *1*, **34**: 779; 12.

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(770) Knudsen, *8*, **29**: 179; 09. (771) Knudsen, *8*, **32**: 809; 10. (772) Knüpffer, *7*, **26**: 255; 98. (773) Kohlrausch, *7*, **12**: 773; 93. (774) Kohlrausch, *7*, **64**: 129; 08. (776) Kohlschütter and Eydmann, *13*, **398**: 1; 13. (777) Kohner, *Diss.*, Berlin, 1914. (778) Kolthoff, *93*, **109**: 69; 19. (779) Kolthoff, *176*, **16**: 1134; 19.

(780) Kolthoff, *70*, **42**: 973; 23. (781) Kolthoff, *70*, **42**: 969; 23. (782) Kolthoff, *Gebrauch der Farbenindikatoren.* Berlin, Springer, 1923. (783) Kolthoff, *70*, **43**: 207; 24. (784) Kolthoff, *70*, **43**: 216; 24. (785) Kopp, *13*, **Suppl. 3**: 289; 65. (786) Kopp, *62*, **155**: 71; 65. (787) Koppel, *93*, **67**: 293; 10. (788) Koppel and Holtkamp, *93*, **67**: 266; 10. (789) Koref, *93*, **66**: 73; 10. (789.5) Koref and Braune, *9*, **18**: 818; 12.

(790) Koster, *see* (852). (791) Kovách, *7*, **80**: 107; 12. (792) Krahmer, *9*, **26**: 97; 20. (793) Kraus, *1*, **30**: 653; 01. (794) Kraus and Hurd, *1*, **45**: 2559; 23. (795) Krauss and Gerlach, *93*, **140**: 61; 24. (795.5) Kremann and Rodemund, *57*, **35**: 1061; 14. (796) Kremann, Zoft, and Ostwald, *57*, **43**: 139; 22. (797) Kremers, *8*, **85**: 246; 52. (798) Kröner, *8*, **40**: 438; 13. (799) Kruyt, *7*, **64**: 513; 08.

(800) Kullgren, *7*, **85**: 466; 13. (801) Kuriloff, *504*, **1**: 1; 95. (802) Kuriloff, *93*, **15**: 344; 97. (803) Kurnakov and Puschin, *93*, **30**: 86; 02. (803.1) van Laar, *7*, **12**: 742; 93. (803.2) van Laar, *64P*, **20**: 492; 18. (803.3) van Laar, *70*, **39**: 647; 20. (804) Labendzinski, *9*, **10**: 77; 04. (805) Lacenko, *Ann. Inst. Polytechnique du Don*, **3**: 59; 14. (806) Lacland and Lapiere, *34*, **113**: 196; 91. (807) Ladenberg, *25*, **35**: 1256; 02. (808) Lajos, *Thesis*, Budapest, 1914. (809) Lamb, *1*, **28**: 1710; 06.

(810) Lamb and Fairhall, *1*, **45**: 378; 23. (811) Lamb and Fonda, *1*, **43**: 1154; 21. (812) Lamb and Larson, *1*, **42**: 2024; 20. (813) Lambert and Gates, *5*, **108**: 456; 25. (814) LaMer, King and Mason, *1*, **49**: 363; 27. (815) LaMer and Mason, *1*, **49**: 410; 27. (816) Lampen, *1*, **28**: 846; 06. (817) Lance, *34*, **124**: 819; 97. (818) Landis, *33*, **22**: 265; 20. (818.5) Lang, *397*, **1888**: 933. (819) Lang and Rigaut, *34*, **129**: 294; 99.

(820) Lange, *7*, **110**: 343; 24. (821) Langmuir, *1*, **28**: 1357; 06. (822) Langmuir, *1*, **34**: 860; 12. (823) Langmuir, *2*, **2**: 329; 13. (824) Langmuir, *2*, **6**: 138; 15. (825) Langmuir, *120*, **29**: 153; 26. (826) Langmuir, *1*, **37**: 417; 15. (827) Langmuir, *1*, **38**: 1145; 16. (828) Langmuir and Mackay, *2*, **4**: 377; 14. (829) Langmuir and Mackay, *1*, **36**: 1708; 14.

(830) Larson, *1*, **46**: 367; 24. (831) Larson and Black, *1*, **47**: 1015; 25. (832) Larson and Dodge, *1*, **45**: 2918; 23. (833) Latimer, *1*, **44**: 90; 22. (834) Latimer and Hoenshel, *1*, **48**: 19; 26. (835) Laudie, *33*, **8**: 22; 10. (836) Lebeau, *34*, **138**: 1496, 1602; 04. (837) Lebeau, *6*, **6**: 422; 05. (838) Le Blanc, *221*, **66**: 38; 14. (839) Le Chatelier, *34*, **102**: 1243; 86.

(840) Le Chatelier, *34*, **115**: 654; 92. (841) Le Chatelier, *34*, **121**: 323; 95. (842) Lemarchands, *74*, **17**: 803; 20. (843) Lescoeur, *6*, **21**: 511; 90. (844) Lescoeur, *6*, **19**: 35, 533; 90. (845) Lescoeur, *6*, **25**: 423; 92. (846) Lescoeur, *6*, **28**: 237; 93. (847) Lescoeur, *6*, **2**: 78; 94. (848) Lescoeur, *6*, **4**: 213; 96. (849) Lescoeur, *6*, **7**: 416; 96.

(850) Lescoeur, *6*, **9**: 537; 96. (851) Lescoeur and Mathurin, *27*, **50**: 33; 88. (852) Levin, *B13*, p. 252. (853) Lewis, *1*, **28**: 158; 06. (854) Lewis, *1*, **28**: 139; 06. (855) Lewis, *1*, **28**: 1380; 06. (856) Lewis, *267*, **1**: 439; 06. (857) Lewis, *7*, **55**: 449; 06. (858) Lewis, *1*, **30**: 668; 08. (859) Lewis, *2*, **18**: 121; 21.

(860) Lewis and Adams, *1*, **37**: 2308; 15. (861) Lewis and Argo, *1*, **37**: 1983; 15. (862) Lewis and Brighton, *1*, **39**: 1906; 17. (863) Lewis and Brighton, *1*, **40**: 482; 18. (864) Lewis, Brighton and Sebastian, *1*, **39**: 2245; 17. (865) Lewis and Burrows, *1*, **34**: 1515; 12. (866) Lewis and Edgar, *1*, **33**: 292: 11. (867) Lewis and Gibson, *1*, **39**: 2554; 17. (868) Lewis, Gibson and Latimer, *1*, **44**: 1008; 22. (869) Lewis and Keyes, *1*, **34**: 119; 12.

(870) Lewis and Keyes, *1*, **35**: 340; 13. (871) Lewis and Keyes, *1*, **40**: 472; 18. (872) Lewis and Kraus, *1*, **32**: 1459; 10. (873) Lewis and Lacey, *1*, **36**: 804; 14. (874) Lewis and Lacey, *1*, **37**: 1976; 15. (875) Lewis and Randall, *1*, **33**: 476; 11. (876) Lewis and Randall, *1*, **34**: 1128; 12. (877) Lewis and Randall, *1*, **36**: 1969; 14. (878) Lewis and Randall, *1*, **36**: 2259; 14. (879) Lewis and Randall, *1*, **36**: 2468; 14.

(880) Lewis and Randall, *1*, **37**: 458; 15. (881) Lewis and Randall, *1*, **38**: 2348; 16. (882) Lewis and Randall, *1*, **40**: 362; 18. (883) Lewis and Randall, *1*, **43**: 233; 21. (884) Lewis and Randall, *1*, **43**: 1112; 21. (885) Lewis and Randall, *Thermodynamics and the free energy of chemical substances.* McGraw-Hill Book Company, New York, 1923. (886) Lewis, Randall and Bichowsky, *1*, **40**: 356; 18. (887) Lewis, Randall, Frost and Spencer, *0*. (888) Lewis and Rupert, *1*, **33**: 299; 11. (889) Lewis and Sargent, *1*, **31**: 355; 09.

(890) Lewis and Storch, *1*, **39**: 2544; 17. (891) Lewis and von Ende, *1*, **32**: 732; 10. (892) Ley and Schäfer, *25*, **39**: 1259; 06. (893) Lind, Underwood and Whittemore, *1*, **40**: 465; 18. (894) Lindner, *57*, **33**: 613; 12. (895) Linebarger, *7*, **13**: 500; 94. (896) Linhart, *1*, **38**: 2356; 16. (897) Linhart, *1*, **39**: 2601; 17. (898) Linhart, *1*, **39**: 615; 17. (899) Linhart, *1*, **40**: 158; 18.

(900) Linhart, *1*, **41**: 1175; 19. (901) Lipscomb and Hulett, *1*, **38**: 20, 889; 16. (902) Lipski, *Diss.*, Braunschweig, 1909. (903) Lloyd, *50*, **12**: 398; 08. (904) Locke and Forssall, *11*, **31**: 268; 04. (905) Long, *11*, **22**: 217; 99. (906) Longi, *36*, **13**: 87; 83. (907) Loomis and Acree, *11*, **46**: 585; 12. (908) Loomis, Essex and Meacham, *1*, **39**: 1133; 17. (909) Loomis and Meacham, *1*, **38**: 2310; 16.

(910) Lorenz, *78*, **47**: 249; 25. (911) Lorenz and Böhi, *7*, **66**: 733; 09. (912) Lorenz, Fraenkel and Ganz, *93*, **153**: 281; 26. (913) Lorenz, Fraenkel and Silberstein, *93*, **131**: 247; 23. (914) Löwenstein, *7*, **54**: 715; 05. (915) Löwenstein, *7*, **54**: 707; 05. (916) Löwenstein, *93*, **63**: 69; 09. (917) Lowry, *5*, **91**: 53; 14. (918) Lowry and Morgan, *1*, **46**: 2192; 24. (919) Lunge, *54*, **4**: 31; 85.

(920) Lunge and Marmier, *see* (408.1). *92*, **1897**: 105. (921) Lurie and Gillespie, *1*, **49**: 1146; 27. (922) Luther, *9*, **11**: 832; 05. (923) Luther and Inglis, *7*, **43**: 203; 03. (924) Luther and Leubner, *93*, **74**: 389; 11. (924.5) Luther and Michie, *9*, **14**: 826; 08. (925) Luther and Pokorny, *93*, **57**: 290; 08. (926) Maass and Hatcher, *1*, **42**: 2548; 20. (927) Maass and Herzberg, *1*, **42**: 2569; 20. (928) Mack, Osterhof and Kraner, *1*, **45**: 617; 23. (929) MacInnes and Parker, *1*, **37**: 1445; 15.

(930) Mackae, *Thesis*, Mass. Inst. Tech., Boston, 1917. (931) Mackay and Ferguson, *143*, **181**: 209; 16. (932) MacRae and Voorhis, *1*, **43**: 547; 21. (933) Maeda, *469*, **2**: 350; 23. (934) Magnus, *63*, **14**: 5; 13. (935) Magnusson, *50*, **11**: 21; 07 (936) Maier, *1*, **48**: 356; 26. (937) Maier, Bureau of Mines, Berkeley, Calif., *0*. (938) Maier, Parks and Anderson, *1*, **48**: 2564; 26. (939) Maier and Ralston, *1*, **48**: 364; 26.

(940) Maier and Ralston, *1*, **49**: 3189; 27. (941) Maier and Ralston, *78*, **51**: 339; 27. (942) Maigret, *27*, **33**: 631; 05. (943) Manchot and Bauer, *93*, **133**: 341; 24. (944) Manchot and Haunschild, *93*, **140**: 22; 24. (945) Manchot, Jahrstorfer and Zepter, *93*, **141**: 45; 24. (946) Manchot and Lorenz, *93*, **134**: 297; 24. (947) Manchot and Ortner, *see* Manchot, *93*, **120**: 300; 22. (948) Marc and Simek, *93*, **82**: 17; 13. (949) Marchal, *34*, **176**: 299; 23.

(950) Marchal, *34*, **177**: 1300; 23. (951) Marchal, *6*, **22**: 493; 25. (952) Marden, *1*, **38**: 310; 16. (953) Marino and Toninelli, *22*, **21 II**: 98; 12. (954) Marshall and Bružs, *50*, **29**: 1184; 25. (955) Maschke, *Diss.*, Karlsruhe, 1911. *See also* (540). (956) Mason, *Thesis*, Columbia University, New York, 1926. (957) Matignon, *6*, **14**: 5; 08. (958) Matignon, *34*, **154**: 772; 12. (959) Matignon, *34*, **156**: 788; 13.

(960) Matignon and Fréjaques, *27*, **29**: 21; 21. (961) Matignon and Fréjaques, *14*, **17**: 257; 22. (962) Matignon and Fréjaques, *27*, **31**: 394; 22. (963) Matsubara, *80*, **67**: 3; 21. (964) Maxted, *54*, **37**: 105T; 18. (965) Mayer, *Diss.*, München, 1908. (966) Mayer and Altmayer, *25*, **40**: 2134; 07. (967) Mayer and Altmayer, *397*, **52**: 326; 09. (968) Mayer and Henseling, *397*, **52**: 166, 194; 09. (969) Mayer and Jacoby, *397*, **52**: 282, 305; 09.

(970) Mazzetti, *22*, **33 II**: 46; 24. (971) Mazzotto, *23*, **17**: 132; 81. (972) McAmis and Felsing, *1*, **47**: 2633; 25. (973) McBain and Kam, *4*, **115**: 1332; 19. (974) McCoy, *11*, **29**: 437; 03. (975) McCoy and Smith, *1*, **33**: 468; 11. (976) McCrae and Wilson, *93*, **35**: 11; 03. (977) McLauchlan, *7*, **44**: 600; 03. (978) Mees and Piper, *204*, **33**: 227; 12. (979) Mellon and Henderson, *1*, **42**: 676; 20.

(980) Mentrel, *34*, **135**: 740; 02. (981) Mentrel, *27*, **29**: 493; 03. (982) Menzel, *7*, **100**: 276; 22. (983) Menzel, *7*, **105**: 402; 23. (984) Menzies, *1*, **41**: 1783; 19. (985) Menzies, *197*, **5**: 558; 19. (986) Menzies, *1*, **42**: 1951; 20. (987) Merrill and Adams, *1*, **39**: 1588; 17. (987.5) Van Meurs. *7*, **91**: 313; 16. (988) Meyer, *Verh. Ges. nat. Ärtze zu Meram, etc.*, III: 94. (989) Meyer, *Thesis*, Paris, 1912.

(990) Meyer, *93*, **81**: 385; 13. (991) Meyer, *93*, **86**: 257; 14. (991.5) von Meyer, *52*, **36**: 292; 87. (992) Meyer and Jannek, *91*, **52**: 534; 13. (994) Meyer and Orthner, *25*, **54B**: 1705; 21. (995) Meyer and Rötgers, *93*, **57**: 104; 08. (996) Meyer and Winter, *93*, **67**: 398; 10. (996.5) Meyerhoffer, *7*, **53**: 513; 05. (997) Michaelis and Mizutami, *7*, **116**: 135; 25. (998) Milbauer, *136*, **33**: 513; 09. (999) Milbauer, *136*, **33**: 522; 09.

(1000) Milbauer, *136*, **33**: 950; 09. (1001) Milbauer, *136*, **33**: 960; 09. (1002) Milbauer, *136*, **34**: 138; 10. (1003) Milbauer, *136*, **34**: 1341; 10. (1004) Milbauer and Kohn, *7*, **91**: 410; 16. (1005) Millar, *1*, **45**: 874; 23. (1006)

Millar, U. S. Bureau of Mines, Berkeley, Calif., *0*. (1007) Millikan, *7*, **92**: 59; 18. (1008) Mitscherlich, *444*, **1852**: 636. (1009) Mitscherlich, *52*, **58**: 239; 53.

(1010) Moldenhauer, *93*, **51**: 369; 06. (1010.5) Moldenhauer and Groebe, *93*, **27**: 334; 14. (1011) Moldenhauer and Roll-Hansen, *93*, **82**: 130; 13. (1012) Moles and Crespi, *7*, **100**: 337; 22. (1013) Mond, Hirtz and Cowap, *135*, **98**: 165; 08. (1014) Mond, Ramsay and Shields, *62*, **191**: 105; 98. (1015) Mond and Wallis, *4*, **121**: 29; 21. (1016) Morey, *1*, **39**: 1173; 17. (1017) Morey and Williamson, *1*, **40**: 59; 18. (1018) Morgen and Hildebrand, *1*, **48**: 911; 26. (1019) Morse, *7*, **41**: 709; 02.

(1020) Mott, *78*, **34**: 255; 18. (1021) Mueller and Burgess, *1*, **41**: 745; 19. (1022) Müller, *9*, **14**: 76; 08. (1023) Müller, *92*, **33**: 303; 20. (1024) Müller, *7*, **105**: 73; 22. (1024.5) Müller, *7*, **110**: 363; 24. (1025) Müller, *7*, **114**: 129; 24. (1025.5) Müller, *92*, **35**: 551; 22. (1026) Müller, *7*, **112**: 161; 24. (1026.5) Müller and Barck, *93*, **129**: 309; 23. (1027) Müller, Müller and Fauvel, *9*, **33**: 134; 27. (1028) Müller and Smith, *1*, **44**: 1909; 22. (1029) Müller-Erzbach, *8*, **27**: 623; 86.

(1030) Müller-Erzbach, *25*, **19**: 2874; 86. (1031) Müller-Erzbach, *25*, **20**: 137; 87. (1032) Müller-Erzbach, *25*, **20**: 1628; 87. (1032.5) Müller-Erzbach, *25*, **20**: 2974; 87. (1033) Müller-Erzbach, *7*, **2**: 539; 88. (1034) Müller-Erzbach, *7*, **4**: 1; 89. (1035) Müller-Erzbach, *7*, **17**: 446; 95. (1036) Müller-Erzbach, *7*, **19**: 135; 96. (1037) Müller-Erzbach, *7*, **21**: 545; 96. (1038) Mündel, *7*, **85**: 435; 13.

(1040) Murray, *4*, **127**: 882; 25. (1041) Muthmann and Baur, *13*, **325**: 281; 02. (1042) Myers and Acree, *11*, **50**: 396; 13. (1043) Naccari, *23*, **23**: 107; 87. (1044) Naumann, *13*, **160**: 1; 71. (1045) Naumann, R., *Diss.*, Berlin, 1907. (1046) Naumann, C., *Diss.*, Leipzig, 1909. (1047) Naumann, *9*, **16**: 772, 778; 10. (1048) Naumann, *9*, **16**: 191; 10. (1049) Naumann and Rücker, *25*, **38**: 2292; 05.

(1050) Niementowski and Roszkowski, *7*, **22**: 145; 97. (1051) Nernst, *7*, **4**: 372; 89. (1052) Nernst, *9*, **9**: 622; 03. (1053) Nernst, *93*, **45**: 126; 05. (1054) Nernst, *93*, **49**: 213; 06. (1054.5) Nernst, *9*, **13**: 521; 07. (1055) Nernst, *9*, **16**: 96; 10. (1056) Nernst and Schwers, *76*, **1914**: 355. (1057) Nernst and von Wartenberg, *188*, **1905**: 35. (1058) Nernst and von Wartenberg, *7*, **56**: 548; 06. (1059) Nernst and von Wartenberg, *9*, **22**: 37; 16.

(1060) Neuberg, *25*, **24**: 2543; 91. (1061) Neumann, *7*, **14**: 193; 94. (1062) Neumann, *92*, **28**: 233; 15. (1063) Neumann, *92*, **34**: 445; 21. (1064) Neumann, *92*, **34**: 457; 21. (1065) Neumann and Jacob, *9*, **30**: 557; 24. (1066) Neumann and Karwat, *9*, **27**: 114; 21. (1067) Nielsen and Brown, *1*, **49**: 2423; 27.

(1070) Nippert, *Diss.*, Breslau, 1913. (1071) Nishizawa, *142*, **23**: 830; 20. (1072) Nonhebel, *3*, **2**: 1085; 26. (1073) Nordmeyer, *26*, **10**: 202; 08. (1074) Nóvacs, *Thesis*, Budapest, 1910. *See* (791). (1075) Noyes, *7*, **6**: 241; 90. (1076) Noyes, *7*, **9**: 603; 92. (1077) Noyes and Abbott, *7*, **16**: 125; 95. (1078) Noyes and Boggs, *1*, **33**: 1650; 11. (1079) Noyes and Brann, *1*, **34**: 1016; 12.

(1080) Noyes and Chapin, *7*, **28**: 518; 99. (1081) Noyes and Ellis, *1*, **39**: 2532; 17. (1081.5) Noyes and Farwell, *1*, **33**: 1654; 11. (1082) Noyes and Freed, *1*, **42**: 476; 20. (1082.1) Noyes, Hall and Beattie, *1*, **39**: 2526; 17. (1083) Noyes and Kanolt, *152*, **No. 63**: 285; 07. (1084) Noyes and Kohr, *1*, **24**: 1141; 02. (1085) Noyes and Ming Chow, *1*, **40**: 739; 18. (1086) Noyes and Schwartz, *1*, **20**: 742; 98. *7*, **27**: 279; 98. (1087) Noyes and Smith, *1*, **43**: 475; 21. (1088) Noyes and Stewart, *1*, **32**: 1133; 10. (1088.5) Noyes and Stewart, *1*, **33**: 1650; 11. (1089) Noyes and Toabe, *1*, **39**: 1537; 17.

(1090) Noyes and Westbrook, *1*, **43**: 726; 21. (1090.5) Noyes and Whitcomb, *1*, **27**: 747; 05. (1091) Noyes and Wilson, Calif. Inst. Tech., Pasadena, Calif., *0*. (1092) Nüranen, *9*, **13**: 297; 07. (1093) Obata, *219*, **2**: 79, 223; 20. (1094) Oberer, *Diss.*, Zürich, 1903. (1095) Ogg, *7*, **22**: 536; 97. (1096) Ogg, *7*, **27**: 285; 98. (1097) O'Hara, *30*, **No. 336**; 24. (1098) Öholm, *147*, **5, No. 4**: 1; 19. (1099) Öholm, *138*, **41**: 1; 12.

(1100) Oliveri-Mandalà, *36*, **45 I**: 303; 15. (1100.5) Olson, *1*, **42**: 896; 20. (1101) Orthner, *Thesis*, Zürich, 1915. (1101.5) Osborne and Van Dusen, *see* (760.5). (1102) Ostwald, *7*, **3**: 170; 89. (1103) Ostwald, *Lehrbuch der allgemeinen Chemie.* Leipzig, 1893. (1104) Ostwald and Heucke, *50*, **29**: 49; 84. (1105) Padoa and Tibaldi, *22*, **12 II**: 158; 03. (1106) Palmaer, *9*, **29**: 415; 23. (1107) Pareau, *13*, **1**: 39; 87. (1108) Parks and Kelley, *50*, **30**: 47; 26. (1109) Parravano and Malquori, *36*, **56**: 3; 26.

(1110) Parsons and Corson, *1*, **32**: 1383; 10. (1111) Parsons and Perkins, *1*, **32**: 1387; 10. (1112) Parsons and Wittemore, *1*, **33**: 1933; 15. (1113) Partington, *4*, **99**: 466; 11. (1114) Partington and Huntingford, *4*, **123**: 160; 23. (1115) Pascal, *14*, **15**: 253; 21. *33*, **25**: 1103, 1145; 21. (1116) Pascal, *34*, **165**: 589; 17. (1117) Paul, *9*, **21**: 542; 15. (1118) Pawelka, *9*, **30**: 180; 24. (1119) Pearce and Fortsch, *1*, **45**: 2852; 23.

(1120) Pease and Chesebro, *1*, **50**: 1464; 28. (1121) Peczi, *Diss.*, Budapest, 1914. (1122) Pélabon, *7*, **26**: 659; 98. (1123) Pélabon, *34*, **128**: 825; 99. (1124) Pélabon, *34*, **131**: 416; 00. **132**: 774; 01. (1125) Pélabon, *34*, **130**: 911; 00. (1126) Pélabon *27*, **23**: 801; 00. (1127) Pellaton, *42*, **13**: 426; 15. (1128) Perman and Atkinson, *7*, **33**: 215, 577; 00. (1129) Perry and Bardwell, *1*, **47**: 2629; 25.

(1130) Pers, *34*, **153**: 673; 11. (1131) Person, *6*, **21**: 295; 47. (1132) Person and Brodie, *see* (1423). (1133) Peters, *93*, **26**: 193; 98. (1134) Peters, *93*, **77**: 186; 12. (1135) Petit, *27*, **37**: 615; 25. (1136) Pick, *B13*, p. 360. (1137) Pier, *7*, **62**: 385; 08. (1138) Pier, *7*, **66**: 759; 09. (1139) Piesse, *25*, **7**: 599; 74.

(1140) Pilling, *2*, **18**: 362; 21. (1141) Pissarjewski, *53*, **40**: 367; 08. (1142) Pissarjewski, *93*, **58**: 399; 08. (1143) Pissarjewski and Litwin, *53*, **42**: 1062; 07. (1144) Pissarjewski and Trachoniotowski, *53*, **42**: 249; 07. (1145) Pissarjewski and Zembicky, *53*, **42**: 537; 07. (1146) Plank, *7*, **100**: 372; 22. (1147) Pleissner, *291*, **26**: 384; 07. (1147.5) Podszuz and Masing, *92*, **30**: 153; 17. (1148) Pohl, *75*, **41**: 263; 60. (1149) Poindexter, *2*, **26**: 859; 25.

(1150) Pollitzer, *93*, **64**: 121; 09. (1151) Pollitzer, *9*, **17**: 5; 11. (1152) Pollitzer, *9*, **19**: 513; 13. (1153) Poma, *7*, **88**: 671; 14. (1154) Pott, *Diss.*, Freiburg, 1905. (1155) Powarnin, *53*, **42**: 207; 10. (1156) Preuner, *7*, **47**: 385; 04. (1157) Preuner, *93*, **55**: 279; 07. (1158) Preuner and Brockmöller, *7*, **81**: 129; 12. (1159) Preuner and Schupp, *7*, **68**: 129; 09.

(1160) Preuner and Schupp, *7*, **68**: 157; 09. (1161) Prideaux, *4*, **91**: 1711; 07. (1162) Prideaux and Ward, *4*, **125**: 423; 24. (1163) Pring and Fairlie, *4*, **101**: 91; 12. (1164) Pullinger and Gardner, *182*, **7**: 2; 91. (1165) Pusch, *9*, **22**: 206; 16. (1166) Rabe, *93*, **31**: 154; 02. (1167) Ramann, University Munich, *0*. (1168) Ramann and Sallinger, *7*, **98**: 103; 21. (1168.5) Ramsay and Young, *4*, **49**: 37; 86. (1169) Ramsay and Young, *4*, **49**: 453; 86.

(1170) Ramsay and Young, *62*, **177**: 71; 86. (1170.5) Randall, *83*, **23**: 498, 502; 27. (1171) Randall and Bichowsky, *1*, **40**: 368; 18. (1172) Randall and Breckenridge, *1*, **49**: 1435; 27. (1173) Randall and Cann, *0*. (1174) Randall and Chang, *1*, **50**: 1535; 28. (1175) Randall and Failey, *286*, **4**: 271; 27. (1176) Randall and Failey, *286*, **4**: 285; 27. (1177) Randall and Failey, *286*, **4**: 291; 27. (1178) Randall and Failey, *1*, **49**: 2678; 27. (1179) Randall and Frandsen, *0*.

(1180) Randall and Girard, *45*, **20**: 1335; 28. (1181) Randall and Halford, *0*. (1182) Randall and James, *0*. (1183) Randall and Langford, *0*. (1184) Randall and Langford, *1*, **49**: 1445; 27. (1185) Randall and McGrane, *0*. (1186) Randall and Nielsen, *0*. (1187) Randall and Ramage, *1*, **49**: 93; 27. (1188) Randall and Scott, *1*, **49**: 647; 27. (1189) Randall and Spencer, *0*. (1189.1) Randall and Spencer, *1*, **50**: 1572; 28.

(1190) Randall and Sosnick, *1*, **50**: 967; 28. (1191) Randall and Tamele, *0*. (1192) Randall and Vietti, *1*, **50**: 1526; 28. (1193) Randall and White, *0*. (1194) Randall and White, *1*, **48**: 2514; 26. (1195) Randall and Young, *1*, **50**: 989; 28. (1196) Rassow, *93*, **114**: 117; 20. (1197) Rây and Jânâ, *4*, **103**: 1565; 13. (1198) Regnault, *6*, **1**: 129; 41. (1199) Reicher, *94*, **8**: 593; 84.

(1200) Reichinstein, *7*, **97**: 257; 21. (1201) Reinders, *64P*, **17**: 703; 14. (1202) Reinders, *64V*, **23**: 596; 14. (1203) Reinders, *93*, **93**: 213; 15. (1204) Reinders and Goudriaan, *93*, **126**: 85; 23. (1205) Reinders and Hamburger, *93*, **89**: 71; 14. (1206) Reinders and Vervloet, *70*, **42**: 625; 23. (1207) Reissmann, *Diss.*, Dresden, 1922. *See* (1025). (1208) Remy, *93*, **137**: 365; 24. (1209) Reynolds and Werner, *4*, **83**: 1; 03.

(1210) Rhead and Wheeler, *4*, **97**: 2178; 10. *182*, **26**: 220; 10. (1211) Rhead and Wheeler, *4*, **99**: 1140; 11. (1212) Rhead and Wheeler, *4*, **101**: 831; 12. (1213) Ribalquine, *134*, **33**: 279; 89. (1214) Ribalquine, *134*, **34**: 165; 91. (1215) Richards, *135*, **68**: 58, 69, 82, 93, 105; 93. (1216) Richards and Behr, *7*, **58**: 301; 07. (1217) Richards and Conant, *1*, **44**: 601; 22. (1218) Richards and Daniels, *1*, **41**: 1732; 19. (1219) Richards and Faber, *11*, **21**: 167; 99.

(1220) Richards and Garrod-Thomas, *7*, **72**: 165; 10. (1221) Richards and Lewis, *65*, **34**: 87; 98. *7*, **28**: 1; 99. (1222) Richards and Matthews, *65*, **46**: 511; 11. (1223) Richards and Smyth, *1*, **44**: 524; 22. (1224) Richardson, *4*, **51**: 397; 87. (1225) Rideal, *45*, **12**: 531; 20. (1226) Riesenfeld, *7*, **45**: 461; 03. (1227) Riesenfeld, *42*, **7**: 561; 09. (1228) Riesenfeld and Beja, *93*, **133**: 245; 24. (1229) Roberts and Smyth, *1*, **43**: 1061; 21.

(1230) Robertson, *4*, **81**: 1233; 03. (1231) Rodebush, *1*, **40**: 1204; 18. (1232) Rodebush, *1*, **45**: 1413; 23. (1233) Rodebush and Dixon, *1*, **47**: 1036; 25. (1234) Rodebush and Dixon, *2*, **26**: 851; 25. (1235) Rodwell, *4*, **15**: 59; 62. (1236) Roebuck, *50*, **6**: 365; 02. (1237) Roebuck, *50*, **9**: 727; 05. (1238) Roederer, *34*, **140**: 1252; 05. (1239) Rolla, *22*, **20 I**: 112; 11.

(1240) Rolla, *36*, **42**: 67; 12. (1241) Rolla and Ansaldo, *22*, **21**: 272; 12. (1242) Roos, *93*, **94**: 329; 16. (1243) Roozeboom, *70*, **3**: 73; 84. (1244) Roozeboom, *70*, **3**: 84; 84. (1245) Roozeboom, *70*, **3**: 29, 59, 84; 84. (1246) Roozeboom, *70*, **4**: 65; 85. (1247) Roozeboom, *70*, **4**: 361; 85. (1248) Roozeboom, *70*, **4**: 108, 331; 85. (1249) Roozeboom, *70*, **5**: 351; 86.

(1250) Roozeboom, *70*, **6**: 374; 87. (1251) Roozeboom, *7*, **2**: 449; 88. (1252) Roozeboom, *7*, **4**: 31; 89. (1253) Roozeboom, *7*, **10**: 477; 92. (1254) Rördam, *Thesis*, Copenhagen, 1925. (1255) Rördam, *7*, **99**: 474; 21. (1256) Rose, *8*, **46**: 353; 1839. (1257) Rose, *13*, **84**: 202; 52. (1258) Rose, *4*, **67**: 881; 95. (1259) Rosenheim and Krause, *93*, **118**: 177; 21.

(1260) Ross, *4*, **105**: 690; 14. (1261) van Rossem, *176*, **9**: 657; 12. (1262) Roth, *7*, **63**: 441; 08. (1263) Roth, *9*, **26**: 288; 20. (1264) Roth and Wallasch, *25*, **46**: 896; 13. (1265) Rothmund, *7*, **33**: 401; 00. (1266) Rothmund, *93*, **31**: 136; 02. (1267) Rothmund, *7*, **69**: 523; 10. (1268) Rothmund and Drucker, *7*, **46**: 827; 03. (1268.5) van Royen, *Diss.*, Bonn, 1911. *See* (852). (1269) Rubenbauer, *93*, **30**: 331; 02.

(1270) Ruby, *1*, **43**: 294; 21. (1271) Rudolfi, *93*, **54**: 170; 07. (1272) Ruer.

93, **50**: 265; 06. (1273) Ruer and Nakamoto, *70*, **42**: 675; 23. (1274) Ruff and Bergdahl, *93*, **106**: 76; 19. (1275) Ruff and Bormann, *93*, **88**: 397; 14. (1276) Ruff and Graff, *93*, **58**: 209; 08. (1277) Ruff and Hartmann, *93*, **133**: 29; 24. (1278) Ruff and Keilig, *93*, **88**: 410; 14. (1279) Ruff and Schmidt, *93*, **117**: 172; 21.

(1280) Russ, *7*, **82**: 217; 13. (1281) Russell, *63*, **13**: 59; 12. (1282) Sabatier, *34*, **158**: 668; 14. (1283) Sackur, *291*, **20**: 512; 03. (1284) Sackur, *9*, **10**: 522; 04. (1285) Sackur and Taegener, *9*, **18**: 718; 12. (1286) Sainte-Claire Deville and Troost, *34*, **49**: 239; 59. (1287) Sainte-Claire Deville and Troost, *6*, **58**: 257; 60. (1288) Sainte-Claire Deville and Troost, *34*, **56**: 895; 63. (1289) Sainte-Claire Deville and Troost, *34*, **91**: 83; 80.

(1290) Salvadori, *36*, **42 I**: 458; 12. (1291) Sammet, *7*, **53**: 641; 05. (1292) Sand, *7*, **48**: 610; 04. (1293) Sandonnini, *22*, **21 II**: 524; 12. (1294) Saposchnikov, *53*, **32**: 375; 00. (1295) Saposchnikov, *7*, **49**: 697; 03. (1296) Saposchnikov, *7*, **51**: 609; 05. (1297) Saposchnikov, *7*, **53**: 225; 05. (1298) Saunders, *50*, **28**: 1151; 24. (1299) Scatchard, *1*, **47**: 641; 25.

(1300) Scatchard, *1*, **47**: 2098; 25. (1301) Scheel and Heuse, *8*, **31**: 715; 10. (1302) Scheffer, *64P*, **18**: 446; 15. (1303) Scheffer, *64P*, **18**: 1498; 16. (1304) Scheffer, *64P*, **19**: 798; 17. (1305) Scheffer and Meyer, *64P*, **21**: 1338; 19. (1306) Scheffer and Treub, *7*, **81**: 308; 13. (1307) Schenck, *9*, **24**: 248; 18. (1308) Schenck and Albers, *93*, **105**: 145; 18. (1309) Schenck and Heller, *25*, **38**: 2132, 2139; 05.

(1310) Schenck and Hempelmann, *187*, **10**: 283; 13. (1311) Schenck and Rassbach, *192*, **4**: 455; 07. (1312) Schenck and Rassbach, *25*, **40**: 2185; 07. (1313) Schenck and Rassbach, *25*, **40**: 2947; 07. (1314) Schenck and Rassbach, *25*, **41**: 2917; 08. (1315) Schenck, Semiller and Falcke, *25*, **40**: 1704; 07. (1316) Schierholz, *75*, **101 IIb**: 4; 90. (1317) Schildbach, *9*, **16**: 967; 10. (1318) Schlesinger, Mullinix and Popoff, *45*, **11**: 317; 19. (1319) Schloesing, *34*, **74**: 1552; 72. **75**: 70; 72. Values corrected by (719).

(1320) Schmidt, *Diss.*, Berlin, 1921. (1321) Schneider, *8*, **107**: 605; 59. (1321.5) Schoch, *11*, **41**: 208, 232; 09. (1322) Schoch and Felsing, *1*, **38**: 1928; 16. (1323) Schoen, *192*, **8**: 737; 11. (1324) Scholvien, *Diss.*, Berlin, 1913. (1325) Schottky, *7*, **64**: 415; 08. (1326) Schraube, *Diss.*, Berlin Tech. Hoch., 1911. (1327) Schreber, *7*, **24**: 651; 97. (1328) Schreinemakers, *7*, **68**: 83; 09. (1329) Schreinemakers and Figee, *176*, **8**: 683; 11.

(1330) Schreiner, *93*, **122**: 201; 22. (1331) Schreiner, *7*, **111**: 419; 24. (1332) Schreiner and Grimnes, *93*, **110**: 311; 20. (1333) Schübel, *93*, **87**: 81; 14. (1334) Schümann, *25*, **33**: 527; 00. (1335) Schumb, *1*, **45**: 342; 23. (1336) Seelig, *Thesis*, Zürich, 1919. (1337) Seibert, Hulett and Taylor, *1*, **39**: 38; 17. (1338) Seidell and Smith, *50*, **8**: 493; 04. (1339) Sénéchal, *34*, **156**: 552; 13.

(1340) Seyler and Lloyd, *4*, **95**: 1347; 09. (1341) Seyler and Lloyd, *4*, **111**: 138; 17. (1342) Shaffer and Hartmann, *141*, **45**: 349; 21. (1343) Sherrill, *7*, **43**: 705; 03. (1344) Sherrill and Noyes, *1*, **48**: 1861; 26. (1345) Sherrill and Russ, *1*, **29**: 1661; 07. (1346) Shields, *7*, **12**: 167; 93. (1347) Sherwood, *45*, **17**: 745; 25. (1348) Shukoff, *25*, **38**: 2691; 05. (1348.5) Siegel, *7*, **87**: 641; 14. (1349) Sieverts, *7*, **88**: 451; 14.

(1350) Siggel, *9*, **19**: 340; 13. (1351) Simons, *1*, **46**: 2179; 24. (1352) Simons and Hildebrand, *1*, **46**: 2183; 24. (1353) Sieverts and Fritzsche, *93*, **133**: 1; 24. (1354) Sieverts and Fritzsche, *93*, **133**: 17; 24. (1355) Skrabal, *57*, **32**: 815; 10. (1356) Skrabal, *9*, **17**: 665; 11. (1357) Skrabal, *75*, **123 II**: 654; 14. (1358) Skrabal, *57*, **35**: 1157; 16. (1359) Slade, *9*, **17**: 261; 11.

(1360) Slade, *93*, **77**: 457; 12. (1361) Slade and Farrow, *5*, **87**: 524; 12. (1362) Slade and Higson, *5*, **87**: 519; 12. (1363) Slade and Higson, *133*, **1913**: 451; 14. (1364) Slade and Higson, *135*, **108**: 166; 14. (1365) Slade and Higson, *4*, **115**: 215; 19. (1366) Slade and Higson, *4*, **115**: 205; 19. (1367) Smith, *2*, **17**: 193; 03. (1368) Smith, *2*, **33**: 173; 11. (1369) Smith, *1*, **40**: 879; 18.

(1370) Smith, *1*, **40**: 883; 18. (1371) Smith and Calvert, *1*, **36**: 1363; 14. (1372) Smith and Calvert, *1*, **38**: 801; 16. (1373) Smith and Carson, *7*, **77**: 661; 11. (1374) Smith and Holmes, *7*, **42**: 469; 03. (1375) Smith and Holmes, *7*, **54**: 257; 05. (1376) Smith and Lombard, *1*, **37**: 38; 15. (1377) Smith and Lombard, *1*, **37**: 2055; 15. (1378) Smith and Menzies, *1*, **32**: 1434; 10. (1379) Smith and Menzies, *1*, **32**: 1412; 10.

(1380) Smith and Menzies, *1*, **32**: 1541; 10. (1381) Smith and Woods, *1*, **45**: 2632; 23. (1382) Smits, *64V*, **32**: 353; 23. (1383) Smits and Bokhorst, *64P*, **17**: 678, 962, 973; 15. (1384) Smits and Bokhorst, *64V*, **23**: 664, 930, 941; 14. (1385) Smits and Bokhorst, *64P*, **18**: 106; 15. (1386) Smits and Bokhorst, *7*, **91**: 249; 16. (1387) Smits, Bokhorst and Terwin, *64P*, **16**: 1174; 14. (1388) Smits, Meyer and Beck, *64P*, **18**: 992; 15. (1389) Smits and Wuite, *64V*, **18**: 225; 09.

(1390) Smyth, *Thesis*, Mass. Inst. Tech., Boston, 1915. (1390.5) Smyth and Adams, *1*, **45**: 1167; 23. (1391) Smyth and Roberts, *1*, **42**: 2582; 20. (1392) Soper, *4*, **125**: 2227; 24. (1393) Sosman and Hostetter, *1*, **38**: 807; 16. (1394) Sosman, Hostetter and Mervin, *128*, **5**: 563; 16. (1395) Spencer, *9*, **11**: 681; 05. (1396) Sproesser and Taylor, *1*, **43**: 1782; 21. (1397) Stahl, *192*, **4**: 682; 07. (1398) Starck, *Diss.*, Stockholm, 1915. (1399) Starck and Bodenstein, *9*, **16**: 961; 10.

(1400) Stasevich, *53*, **43**: 354; 11. (1401) Stegmüller, *9*, **16**: 85; 10. (1402) Steinwehr, *7*, **38**: 185; 01. (1403) Stern, *8*, **44**: 497; 14. (1404) Sterner, *Diss.*, Stuttgart, 1894. (1405) Stock, Henning and Kuss, *25*, **54B**: 1119; 21. (1406) Stock and Seelig, *25*, **52**: 672; 19. (1407) Stock, Siecke and Pohland, *25*, **57B**: 719; 24. (1408) Stoffel, *176*, **8**: 722; 11. (1409) Stoffella, *Boll. chim. farm.*, **64**: 481; 25.

(1410) Straub, *7*, **77**: 331; 11. (1411) Strömholm, *93*, **38**: 429; 04. (1412) Stubbs, *4*, **103**: 1445; 13. (1413) Sucheini, *9*, **12**: 726; 06. (1414) Sugden, *4*, **1926**: 174. (1414.5) Sullivan, *1*, **27**: 529; 05. (1415) Swan, *see* Harkins, *1*, **33**: 1807; 11. (1416) Swan, *Thesis*, Mass. Inst. Tech., Boston, 1899. (1417) Szarvasy and Messinger, *25*, **30**: 1343; 97. (1418) Tamele, *50*, **28**: 502; 24. (1419) Tammann, *504*, **35**: No. 9; 87.

(1420) Tammann, *7*, **2**: 42; 88. (1421) Tammann, *8*, **63**: 16; 97. (1422) Tammann, *7*, **27**: 323; 99. (1423) Tammann, *Kristallisieren und Schmelzen*, 275; 1903. (1424) Tammann and Pape, *93*, **127**: 43; 23. (1425) Tananaeff, *7*, **114**: 49; 24. (1426) Taylor, *1*, **38**: 2295; 16. (1427) Taylor and Hulett, *50*, **17**: 565; 13. (1428) Taylor and Hulett, *1*, **44**: 1443; 22. (1429) Taylor and Perrott, *1*, **43**: 484; 21.

(1430) Terres and Brückner, *9*, **26**: 25; 20. (1431) Terres and Pongracz, *9*, **25**: 386; 19. (1432) Terres and Schaller, *397*, **65**: 761, 780, 800, 818, 852; 22. (1433) Terwin, *Diss.*, Amsterdam, 1913. (1434) Thiel, *93*, **24**: 1; 00. (1435) Thiel and Strobecker, *25*, **47**: 945; 14. (1436) Thin and Cumming, *4*, **107**: 361; 15. (1437) Thompson, *65*, **45**: 431; 09. (1438) Thompson, *78*, **16**: 197; 09. (1439) Thompson, *33*, **8**: 279, 324; 10.

(1440) Thompson and Lombard, *65*, **46**: 247; 10. (1441) Thorpe and Hambly, *4*, **55**: 163; 89. (1442) Tiede and Birnbräuer, *93*, **87**: 129; 14. (1443) Tolman and Ferguson, *1*, **34**: 232; 12. (1444) Tolman and Greathouse, *1*, **34**: 364; 12. (1445) Trautz, *9*, **14**: 534; 08. (1446) Trautz, *93*, **88**: 285; 14. (1447) Trautz, *9*, **21**: 329; 15. (1448) Trautz, *93*, **104**: 169; 18. (1449) Trautz and Dalal, *93*, **102**: 149; 18.

(1450) Trautz and Geissler, *93*, **140**: 116; 24. (1451) Trautz and Gerwig, *93*, **134**: 417; 24. (1452) Trautz and Stäckel, *93*, **122**: 81; 22. (1453) Trautz and Wackenheim, *93*, **97**: 241; 16. (1454) Treadwell, *93*, **37**: 326; 03. (1455) Treadwell and Reuter, *93*, **17**: 170; 98. (1456) Trimble, *1*, **44**: 451; 22. (1457) Troost, *34*, **88**: 578; 79. (1458) Troost, *34*, **92**: 715; 81. (1459) Troost, *34*, **94**: 789; 82.

(1460) Troost and Hautefeuille, *34*, **66**: 795; 68. (1461) Troost and Hautefeuille, *34*, **78**: 686; 74. (1462) Troost and Hautefeuille, *6*, **2**: 273; 74. *34*, **78**: 807; 74. (1463) Truthe, *93*, **76**: 161; 12. (1463.5) Unmach and Bjerrum, *see* (121). (1464) Vágó, *Thesis*, Budapest. (1465) Valenta, *75*, **103 IIb**: 191; 94. *57*, **15**: 249; 94. (1466) Van Name and Brown, *12*, **44**: 105; 17. (1467) Van Name and Brown, *12*, **44**: 453; 17. (1468) Varet, *6*, **8**: 79; 96. (1469) Villard, *34*, **106**: 1062; 88.

(1470) Villard, *34*, **107**: 395; 88. (1471) Villard, *34*, **120**: 1262; 95. (1472) Villard, *51*, **5**: 453; 97. (1473) Villard, *6*, **11**: 289; 97. (1474) Virck, *185*, **1862**: 402. (1475) Voerkelius, *Diss.*, Hanover, 1909. (1476) Voerkelius, *136*, **33**; 1078, 1090; 09. (1477) Vohlendorff, *Diss.*, Berlin, 1891. (1478) Volhard, *25*, **7**: 92; 74. (1479) Volquartz, *see* (207).

(1480) Vosburgh, *1*, **47**: 2531; 25. (1481) Vosburgh, *O*. *See* (471). (1482) Vosburgh, *1*, **49**: 2222; 27. (1482.1) Wrewsky, *7*, **112**: 109; 24. (1482.2) Wrewsky, Sawaritzky and Scharloff, *7*, **112**: 97; 24. (1483) Waddell, *50*, **2**: 525; 98. (1484) Waidner and Burgess, *31A*, **6**: 149; 10. (1485) Walden, *7*, **2**: 49; 88. (1486) Walden, *1*, **30**: 1350; 08. (1487) Walden and Centnerszwer, *7*, **42**: 432; 03. (1488) Walker, *7*, **42**: 207; 02. (1489) Walker, *4*, **127**: 61; 25.

(1490) Walker, Bray and Johnston, *1*, **49**: 1235; 27. (1491) Walker and Cormack, *4*, **77**: 5; 00. (1492) Walker and Hambley, *4*, **67**: 746; 95. (1493) Walker and Lumsden, *4*, **71**: 428; 97. (1494) Walker and Kay, *4*, **71**: 489; 97. (1495) von Wartenberg, *7*, **56**: 513; 06. (1496) von Wartenberg, *88*, **8**: 97; 06. (1497) von Wartenberg, *93*, **52**: 299; 07. (1498) von Wartenberg, *93*, **56**: 320; 08. (1499) von Wartenberg, *93*, **79**: 71; 12.

(1500) von Wartenberg, *9*, **19**: 489; 13. (1501) von Wartenberg, *9*, **19**: 482; 13. (1502) von Wartenberg, *9*, **20**: 443; 14. (1503) von Wartenberg, *7*, **110**: 285; 24. (1504) von Wartenberg and Sieg, *25*, **53**: 2192; 20. (1505) von Wartenberg and Weigel, *93*, **142**: 337; 25. (1506) Wasastjerna, *138*, **1**: No. 39; 23. (1507) Washburn and Strachan, *1*, **35**: 681; 13. (1508) Wasjuchnowa, *Diss.*, Berlin, 1909. (1509) Weber, *93*, **21**: 305; 99.

(1510) Wegscheider, *7*, **65**: 97; 09. (1511) Weigert, *8*, **24**: 55; 07. (1512) von Weimarn, *7*, **76**: 212; 11. (1513) Weisberg, *Thesis*, Mass. Inst. Tech., Boston, 1915. (1514) Wells, *128*, **5**: 617; 15. (1515) Wells, *128*, **5**: 491; 15. (1516) Wells and McAdams, *1*, **29**: 721; 07. (1517) Wenger, *Thesis*, Geneva, 1911. (1518) Wescott, *1*, **42**: 1335; 20. (1519) Whitby, *93*, **67**: 107; 10.

(1520) White, *O*. *See* (939). (1521) White and Kirschbaum, *1*, **28**: 1343; 06. (1522) Whitman and Evans, *33*, **27**: 686; 22. (1523) Whitney and Melcher, *1*, **25**: 69; 03. (1524) Wiedemann, *8*, **Jubelband**: 481. (1525) Wiedemann, Stelzner and Niederschulte, *26*, **3**: 159; 05. (1526) Wigand, *7*, **75**: 235; 11. (1527) Wilhelm, *143*, **182**: 525; 16. (1528) Wilhelm, *31*, **No. 204**; 1916. (1529) Willcox and Prideaux, *4*, **127**: 1543; 25.

(1530) Williams, *Thesis*, University of California, 1922. (1531) Wilson, *1*, **43**: 704; 21. (1532) Winkler, *Diss.*, Leipzig, 1910. (1533) Winteler, *9*, **7**: 360; 00. (1534) Wirth, *93*, **76**: 174; 12. (1535) Wirth, *93*, **79**: 357; 13. (1536) Wirth, *93*, **87**: 9; 14. (1537) Wöhler, *9*, **12**: 781; 06. (1538) Wöhler and Balz, *9*, **27**: 406; 21. (1539) Wöhler and Grünzweig, *25*, **46**: 1726; 13.

(1540) Wöhler and Grünzweig, *25*, **46**: 1587; 13. (1541) Wöhler and Gunther, *9*, **29**: 276; 23. (1542) Wöhler and Prager, *9*, **23**: 199; 17. (1543) Wöhler

and Streicher, *25*, **46**: 1577; 13. (1544) Wöhler and Streicher, *25*, **46**: 1591; 13. (1544.5) Wörmann, *8*, **18**: 775; 05. (1545) Wohl, *7*, **110**: 166; 24. (1546) Wohl, *9*, **30**: 36; 24. (1547) Wohl, *9*, **30**: 49; 24. (1548) Wolff, *9*, **20**: 19; 14. (1549) Wolffenstein, *25*, **27**: 3307; 94.
(1550) Wood, *4*, **93**: 411; 08. (1551) Wood, *4*, **97**: 878; 10. (1552) Worthing, *2*, **10**: 377; 17. (1553) Wourtzel, *34*, **169**: 1397; 19. (1554) Wroblewski, *34*, **94**: 212; 82. (1555) Wüst and Durrer, *414*, **No. 241**; 21. (1556) Wüst, Meuthen and Durrer, *243*, **39**: 294; 19. *414*, **No. 204**; 18. (1557) Wuite, *7*, **86**: 349; 14. (1558) Wuth, *25*, **35**: 2415; 02. (1559) Yoshida, *41*, **48**: 435; 27.
(1560) Zavriev, *42*, **7**: 31; 09. (1561) von Zawidzki, *25*, **36**: 1427; 03. (1562) von Zawidzki, *25*, **37**: 153; 14. (1563) von Zawidzki, *25*, **37**: 2289; 14.

OPTICAL ROTATORY POWER OF SOLID CRYSTALS

W. T. Astbury

Optically active crystals exist in two enantiomorphous forms having equal and opposite rotatory powers for light of a given wave-length. No isotropic substances (cubic crystals) exhibit optical rotation when in solution, but some do when in crystal form. Rotatory power = θ/l where θ is the angle through which the plane of polarization is rotated while plane polarized light is passing a distance l through the crystal in the direction of an optic axis. In some cases the variation of θ/l with the wave-length (λ) can be represented by an empirical Drude equation $\theta/l = k/(\lambda^2 - \lambda_0^2)$. Temperature is stated whenever it is given in the published paper, in other cases it is presumably room temperature. $t[T]$ = centigrade (°C) [absolute (°K)] temperature. Iso = isotropic (cubic crystal), Uni = uniaxial, Bi = biaxial, *d*- [*l*-] = dextro- [levo-] rotatory. "*d*-solutions → *l*-crystals" means that levorotatory crystals form from a solution which is dextrorotatory. Yes [No] means that solutions of the substance are [are not] active. A = accuracy; example: For HIO_3, λ = 0.436, $\theta/l = (74.5 \pm 0.7)$ degrees per mm.

𝔅-TABLE, STANDARD ARRANGEMENT

Unit of θ/l and of A = 1° per mm; of $\lambda = 1\mu = 10^4$ Å $= 10^{-4}$ cm

HIO_3 Iodic acid (12), Bi, No, dimorphous, both forms are orthorhombic bisphenoidal; prism angle of specimen = 86°23′

λ	θ/l	A
0.436	74.5	0.7
0.546	58.7	0.6
0.579	50.5	0.5

$N_2H_4.H_2SO_4$, Hydrazine sulfate (12), Bi, No

0.436	4.00	0.08
0.546	3.05	0.06
0.579	2.80	0.06

C-Compounds, *v.* p. 354

SiO_2, *v.* Vol. VI, p. 342

$PbS_2O_6.4H_2O$, Lead dithionate (18, 19), Uni, No, 20°C

0.5461	6.57	0.03
0.5893	5.46	0.03

If $0.4047 < \lambda < 0.7188$, k = 1.601, $\lambda_0^2 = 0.0541$, A = 1% of k

$Pb(CHO_2)_2$, Lead formate (12), Bi, No

0.436	39.4	2.0
0.546	18.0	0.9
0.579	15.6	0.8

$ZnSO_4.7H_2O$, Zinc sulfate (12), Bi, No

λ	θ/l	A
0.436	4.05	0.08
0.546	2.72	0.05
0.579	2.41	0.04

$Zn(C_4H_5O_5)_2.2H_2O$, Zinc malate (25), Uni, Yes, *l*-crystals→*l*-solutions

0.5893	3.0	0.2

HgS, Cinnabar* (17, 19), Uni, No, 20°C

0.5893	560	10
0.6022	480	8
0.7188	140	5

If $0.6103 < \lambda < 0.6870$, k = 33.65, $\lambda_0^2 = 0.2915$, A = 1% of k

* For $\lambda = 0.6438$, $(\theta/l)_T = 237.5 \times (1.00421 - 0.00056T + 0.00000355 T^2)$, A = 0.5 %, $87°K < T < 277°K$; and $(\theta/l)_t = 264(1 + 0.001t)$, A = 1 %, $4°C < t < 22°C$. For λ = 0.6708, $t = -184.5°C$, $\theta/l = 190 \pm 1$; for λ = 0.5893, $t = -187.4°C$, $\theta/l = 142 \pm 1$. *See* (17, 19).

$NiSO_4.7H_2O$, Nickel sulfate (12), Bi, No

λ	θ/l	A
0.546	6.30	0.31
0.579	6.10	0.30

$(MoO_4)_2C_4H_6O_5(NH_4)_2.2H_2O$, Ammonium molybdomalate (12), Bi, Yes, *d*-solutions → *l*-crystals

0.436	72.87	0.73
0.546	37.2	0.4
0.579	32.3	0.3
0.5893	30.8	0.3

$MgSO_4.7H_2O$, Magnesium sulfate (12), Bi, No

0.436	3.18	0.03
0.546	2.30	0.02
0.579	1.98	0.02

$MgCrO_4.7H_2O$, Magnesium chromate (12), Bi, No

0.436	8.13	0.08
0.546	6.74	0.07
0.579	5.59	0.06

$CaS_2O_6.4H_2O$, Calcium dithionate (19), Uni, No, 20°C

0.5461	2.74	0.05
0.5893	2.10	0.04

If $0.4047 < \lambda < 0.7188$, k = 0.702, $\lambda_0^2 = 0.0133$, A = 2% of k

$SrS_2O_6.4H_2O$, Strontium dithionate (19), Uni, No, 20°C

0.5461	3.27	0.03
0.5893	2.78	0.03

If $0.4047 < \lambda < 0.6868$, k = 0.894, $\lambda_0^2 = 0.025$, A = 1% of k

$Sr(CHO_2)_2.2H_2O$, Strontium formate (12), Bi, No

0.436	2.0	0.2
0.546	1.0	0.1
0.579	0.75	0.08

$Ba(MoO_4)_2C_4H_6O_5.2H_2O$, Barium molybdomalate (12), Bi, Yes

0.436	78.3	0.8
0.546	41.5	0.4
0.579	33.96	0.34
0.5893	31.68	0.32

$NaClO_3$, Sodium chlorate* (8, 21, 26), Iso, No, 20°C

λ	θ/l	A
0.5461	3.69	0.02
0.5893	3.16	0.01

If $0.3184 < \lambda < 0.7188$, k = 1.078, $\lambda_0^2 = 0.0062$, A = 0.5% of k

* $(\theta/l)_t = (\theta/l)_0 \{1 + \beta t(10)^{-5}\}$; Guye (8) found $\beta = 59 \pm 1$ if $0°C < t < 31°C$ and $0.3821 < \lambda < 0.5893$; Sohncke (21) found $\beta = 61 \pm 6$ if $16°C < t < 148°C$ and $0.4862 < \lambda < 0.5893$.

$NaBrO_3$, Sodium bromate (19, 22), Iso, No, 20°C

0.4047	7.2	0.1
0.5461	2.62	0.02
0.5893	2.13	0.02
0.7188	1.39	0.04

If $0.4102 < \lambda < 0.6867$, k = 0.541, $\lambda_0^2 = 0.092$, A = 1% of k

$NaIO_4.3H_2O$, Sodium periodate (7), Uni, No

0.4308	47.1	0.7
0.4862	34.2	0.2
0.5270	28.5	0.4
0.5893	23.3	0.1
0.6563	19.4	0.5

$NaH_2PO_4.2H_2O$, Sodium dihydrogen phosphate (6), Bi, No

0.5893	4.5	0.4

$Na_3SbS_4.9H_2O$, Sodium sulfantimoniate (16), Iso, No

0.556	2.7	0.3

$NaNH_4C_4H_4O_6.4H_2O$, Sodium ammonium tartrate (6), Bi, Yes, *d*-solutions → *l*-crystals

0.5893	1.55	0.15

$NaUO_2(C_2H_3O_2)_3$, Sodium uranyl acetate (22), Iso, No

0.5893	1.48	0.05

$K_2S_2O_6$, Potassium dithionate (18, 19), Uni, No, 20°C

0.5461	9.67	0.05
0.5893	8.20	0.04

If $0.4047 < \lambda < 0.7188$, k = 2.664, λ_0 = 0.0225, A = 1% of k

$K_3Ir(C_2O_4)_3.H_2O$, Potassium iridium trioxalate (15), Uni, Yes

0.579	12.0	0.6

$K_3Rh(C_2O_4)_3.H_2O$, Potassium rhodium trioxalate (14), Uni, Yes, solution has similar dispersion of rotation, but inversion is at $\lambda = 0.597$ instead of 0.519

λ	θ/l	A
0.490	+5.1	0.1
0.500	+2.8	0.06
0.520	−1.0	0.02
0.540	−2.6	0.05
0.560	−4.8	0.1
0.580	−6.4	0.1
0.600	−7.4	0.1
0.620	−8.4	0.2
0.640	−8.9	0.2
0.660	−9.1	0.2
0.680	−8.8	0.2
0.700	−8.4	0.2

$K_4Mo_{12}SiO_{40}.18H_2O$, Potassium silicomolybdate (4), Uni, No

0.5893	17.2	0.3

$K_4W_{12}SiO_{40}.18H_2O$, Potassium silicotungstate (30), Uni, No

λ	θ/l	A
0.5893	14.4	0.2

$LiKSO_4$, Lithium potassium sulfate (23), Uni, No

0.5893	3.5	0.2

$K_2SO_4.Li_2CrO_4$, Potassium lithium sulfochromate (23), Uni, No

0.5893	1.9	0.2

$KNaC_4H_4O_6.4H_2O$, Rochelle salt (6), Bi, Yes, *d*-solutions → *d*-crystals

0.5893	1.35	0.15

$Rb_2C_4H_4O_6$, Rubidium tartrate (24, 29), Uni, Yes, *d*-solutions → *l*-crystals

0.5893	10.4	0.2

$Cs_2C_4H_4O_6$, Cesium tartrate (24), Uni, Yes, *d*-solutions → *l*-crystals

0.5893	17	3

ℭ-TABLE, STANDARD ARRANGEMENT

v. Vol. III, p. viii

$(COONH_4)_2.H_2O$, Ammonium oxalate (12), Bi, No

λ	θ/l	A
0.436	20.0	0.4
0.546	13.7	0.3
0.579	12.0	0.2

$C_2H_4(NH_2)_2.H_2SO_4$, Ethylenediamine sulfate (11), Uni, No

0.5893	15.5	0.3

$(CH_5N_3)_2.H_2CO_3$, Guanidine carbonate (2), Uni, No

0.5351	17.1	0.2
0.5893	14.6	0.3
0.6708	12.6	0.1

$C_4H_4O_6$, Tartaric acid (13), Bi, Yes, *d*-solutions (aqueous) → *l*-crystals

0.436	24.0	0.2
0.546	13.0	0.1
0.589	10.7	0.1
0.650	9.1	0.1

If $0.480 < \lambda < 0.600$, $k = 2.80$, $\lambda_0^2 = 0.0839$, $A = 1\%$ of k

$C_4H_4O_6(NH_4)_2$, Ammonium tartrate (12), Bi, Yes

λ	θ/l	A
0.436	16.0	0.3
0.546	14.0	0.3
0.579	8.9	0.2
0.5893	8.8	0.2

$C_4H_4O_6(SbO)NH_4.H_2O$, Ammonium antimonyl tartrate (27), Bi, Yes

0.491	24.9	0.6
0.536	18.5	0.4
0.570	16.8	0.4
0.620	13.9	0.3

$C_4H_8N_2O_3.H_2O$, Asparagine (12), Bi, Yes, *l*-solutions → *l*-crystals

0.436	9.7	0.2
0.546	7.2	0.1
0.579	6.2	0.1
0.5893	5.9	0.1

$C_6H_{12}O_5$, Quercitol (10), Bi, Yes

"Weak" axis

0.5461	4.5	0.2
0.5893	3.7	0.2

If $0.4862 < \lambda < 0.6868$, $k = 1.04$, $\lambda_0^2 = 0.067$, $A = 4\%$ of k

"Strong" axis

0.5270	6.4	0.4
0.5550	5.9	0.3
0.5893	4.6	0.3
0.6563	3.9	0.3

$C_7H_{14}O_6$, *d*-Methyl-α-glucoside (6), Bi, Yes, *d*-solution → *d*-crystals

λ	θ/l	A
0.5893	4.4	0.3

$C_{10}H_{16}O$, Camphor (common, Laurus) (20), Uni, Yes

0.4308	1.82	0.02
0.5893	0.65	0.01
0.6868	0.46	0.01

$C_{12}H_{20}O$, Matico camphor (9, 24), Uni, Yes

0.5351	2.47	0.05
0.5893	1.98	0.06
0.6708	1.68	0.05

$C_{14}H_{10}O_2$, Benzil (5), Uni, No

0.5893	25.0	0.3

$C_{15}H_{26}O$, Patchouli camphor (24), Uni, Yes. All crystals seen were levo

0.5893	1.33	0.02

$C_{17}H_{20}O$, Benzylidenecamphor (12), Bi, Yes, *d*-solutions → *d*-crystals

0.436	20.2	0.4
0.546	10.0	0.2
0.579	8.6	0.2
0.5893	8.18	0.16

$C_{18}H_{22}O_2$, Anisalcamphor (12), Bi, Yes, *d*-solutions → *l*-crystals

λ	θ/l	A
0.436	82.0	0.8
0.546	44.0	0.4
0.579	38.0	0.4
0.5893	36.2	0.4

$C_{20}H_{23}NO_4$, *d*-Corydine (1), Uni, Yes

0.5351	14.6	0.2
0.5893	13.2	0.2
0.6708	10.5	0.2

$C_{24}H_{18}O_6$, Diacetylphenolphthalein (3), Uni, No

0.5351	23.8	0.2
0.5893	19.8	0.1
0.6708	17.1	0.2

$(C_{19}H_{24}N_2O)_2.H_2SO_4.11H_2O$, Hydrocinchonine sulfate (31), Uni, Yes, all crystals are dextro

0.5893	12.8	0.1

$(C_{21}H_{22}N_2O_2)_2.H_2SO_4.6H_2O$, Strychnine sulfate (22, 31), Uni, Yes, *l*-crystals → *l*-solutions

0.5893	13.25	(?)
0.5893	10.9	(?)

$(C_{19}H_{24}N_2O)_2(SbO)_2C_4H_4O_6.5H_2O$, Cinchonine antimonyl tartrate (25), Uni, Yes, *d*-solution → *d*-crystals

0.5893	9.8	0.1

$(C_{19}H_{22}N_2O)_2.C_4H_6O_4.6H_2O$, Apocinchonine succinate (28), Uni, Yes

0.5893	3.5	0.5

LITERATURE

(For a key to the periodicals see end of volume)

(1) Blass, *94*, **48**: 20; 11. (2) Bodewig, *8*, **157**: 122; 76. (3) Bodewig, *94*, **1**: 72; 77. (4) Copaux, *6*, **7**: 118; 06. (5) Des Cloizeaux, *34*, **68**: 308; 69. **70**: 1209; 70. (6) Dufet, *51*, **3**: 757; 04. (7) Groth, *8*, **137**: 433; 69. (8) Guye, *149*, **22**: 130; 89. (9) Hintze, *8*, **157**: 127; 76.

(10) Karandyeev, *134*, **9**: 1285; 15. (11) von Lang, *75*, **65 II**: 30; 72. (12) Longchambon, *191*, **45**: 161; 22. *34*, **172**: 1187; 21. **173**: 89; 21. **175**: 174; 22. *Thesis*, Paris, 1923. (13) Longchambon, *34*, **178**: 951; 24. (14) Longchambon, *34*, **178**: 1828; 24. (15) Longchambon, Univ. Nancy, *0*. (16) Marbach, *8*, **99**: 451; 56. (17) Molby, *2*, **31**: 291; 10. (18) Pape, *8*, **139**: 224; 70. (19) Rose, *190B*, **29**: 53; 10.

(20) von Seherr-Thoss, *in* Traube, *94*, **23**: 577; 94. (21) Sohncke, *8*, **3**: 516; 78. (22) Traube, *B3*, 2nd ed., 1894; p. 459, 460. (23) Traube, *190*, **1**: 171; 94. (24) Traube, *76*, **1895**: 195. (25) Traube, *190B*, **11**: 623; 97. (26) Voigt, *63*, **9**: 585; 08. (27) Wallerant, *34*, **158**: 91; 14. (28) Wyrouboff, *6*, **1**: 5; 94. (29) Wyrouboff, *51*, **3**: 451; 94.

(30) Wyrouboff, *191*, **19**: 219; 96. (31) Wyrouboff, *191*, **24**: 76; 01.

OPTICAL ROTATORY POWER OF LIQUIDS AND SOLUTIONS[1]

THOMAS MARTIN LOWRY

ARRANGEMENT

Arrangement is by classes defined as follows:

Carbon Compounds*

I. None of the asymmetric carbon atoms forms part of a ring.

II. At least one asymmetric carbon atom forms part of a ring.

III. The compound contains no asymmetric carbon atom or contains at least one asymmetric or dissymmetric atom other than carbon.

IV. Substances of unknown, doubtful or complex structure.

Classes I to IV are subdivided according to the number and nature of the asymmetric atoms as follows:

A_n The molecule contains n asymmetric atoms which are attached each to only one other carbon atom.

B_n The molecule contains n asymmetric atoms which are attached each to two other carbon atoms.

C_n The molecule contains n asymmetric atoms which are attached each to three other carbon atoms.

D_n The molecule contains n asymmetric atoms which are attached each to four other carbon atoms.

For substances which fall within two or more of the above subdivisions the higher (in the order D, C, B, A) division receives preference in deciding the arrangement. Within a subdivision the arrangement is in accordance with the value of n in the order 1, 2, 3, etc.

SYMBOLS AND ABBREVIATIONS

t	Temperature in degrees centigrade (°C).
λ	Wave length of light expressed in Ångstrom units, *i.e.*, in tenths of a millimicron ($\frac{1}{10}\mu\mu$) unless otherwise indicated.
D	A wave length of 5893 Å.
α_λ^t	Observed rotation at the given values for t.
$[\alpha]_\lambda^t$	Specific rotation at the given values for t.
$[M]_\lambda^t$	Molecular rotation at the given values for $t (= M \times [\alpha]_\lambda^t/100)$.
C	Concentration in grams per 100 cm³ of solution.
%	Concentration in grams per 100 grams of solution (= Wt. %). (Values in italics.)
d	d_4^t = density at the given value for t referred to water at 4°C, unless otherwise indicated.
2% NaOH (etc.)	2% of solution of NaOH in water.
2% NaOH MeOH	2% of solution of NaOH in methyl alcohol.
M	Moles.
N NaOH	Normal aqueous solution of NaOH (= 1 equivalent/liter).

ARRANGEMENT

Arrangement par classes, définies comme suit:

Composés du carbone

I. Aucun des atomes de carbone asymétriques ne fait partie d'une chaine cyclique.

II. Un atome de carbone asymétrique au moins fait partie d'une chaine cyclique.

III. Le composé ne contient aucun atome de carbone ou contient au moins un atome asymétrique ou dyssymétrique autre que carbone.

IV. Substances de structure inconnue, douteuse ou complexe.

Les classes I–IV sont subdivisées comme suit, en accord avec le nombre et la nature des atomes asymétriques:

A_n La molécule contient n atomes asymétriques, chacun de ceux-ci étant seulement relié à un autre atome de carbone.

B_n La molécule contient n atomes asymétriques, chacun de ceux-ci étant relié à deux autres atomes de carbone.

C_n La molécule contient n atomes asymétriques, chacun de ceux-ci étant relié à trois autres atomes de carbone.

D_n La molécule contient n atomes asymétriques, chacun de ceux-ci étant relié à quatre autres atomes de carbone.

Lorsqu'une substance est comprise dans deux ou plusieurs subdivisions ci-dessus, on donnera la préférence à la division supérieure (dans l'ordre D, C, B, A) pour décider de l'arrangement. Dans une subdivision, l'arrangement est réalisé en accord avec les valeurs de n, dans l'ordre 1, 2, 3, etc.

SYMBOLES ET ABRÉVIATIONS

t	Température en degrés centigrades (°C).
λ	Longueur d'onde de la lumière exprimée en unités Ångstrom, *i.e.*, en dixièmes de millimicron ($\frac{1}{10}\mu\mu$) à moins d'une autre indication.
D	Une longueur d'onde de 5893 Å.
α_λ^t	Rotation observée pour les valeurs données de t.
$[\alpha]_\lambda^t$	Rotation spécifique pour les valeurs données de t.
$[M]_\lambda^t$	Rotation moléculaire pour les valeurs données de $t (= M \times [\alpha]_\lambda^t/100)$.
C	Concentration en grammes pour 100 cm³ de solution.
%	Concentration en grammes pour 100 grammes de solution (= Pds. %). (Valeurs en italique.)
d	d_4^t = densité pour la valeur donnée de t par rapport à l'eau à 4°C, à moins d'une autre indication.
2% NaOH (etc.)	Solution de NaOH dans l'eau, à 2%.
2% NaOH MeOH	Solution à 2% de NaOH dans l'alcool méthylique.
M	Molécule-gramme ou mole.
N NaOH	Solution aqueuse normale de NaOH (= 1 équivalent/litre).

Symbols for Solvents

A ≡ The acid radical under which it is used.
Ac ≡ (CH_3CO) Acetyl.
Bu ≡ (C_3H_7) Butyl.
En ≡ ($C_2H_8N_2$) α, β-Ethylenediamine.
Et ≡ (C_2H_5) Ethyl.
Me ≡ (CH_3) Methyl.
Ph ≡ (C_6H_5) Phenyl.
Pn ≡ ($C_3H_{10}N_2$) α, β-Propylenediamine.
Py ≡ (C_5H_5N) Pyridine.
Tr ≡ ($C_3H_{10}N_2$) α, γ-Diaminopropane.

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[1] This section includes data and bibliography to January 1, 1924.

* Sugars and their derivatives (*see also* Vol. II, p. 334, 353) are classed as open chain compounds. In general, derivatives are listed under the parent compound, even when they contain additional asymmetric atoms.

ANORDNUNG

Die Anordnung erfolgt nach Klassen, die folgendermassen bestimmt sind:

Kohlenstoffverbindungen

I. Keines der asymmetrische Kohlenstoffatome bildet einen Teil eines Ringes.

II. Wenigstens ein asymmetrisches Kohlenstoffatom bildet einen Teil eines Ringes.

III. Die Verbindung enthält kein asymmetrisches Kohlenstoffatom oder enthält wenigstens ein asymmetrisches oder dissymmetrisches Atom von anderer Natur als Kohlenstoff.

IV. Stoffe unbekannter, zweifelhaftiger oder komplexer Struktur.

Die Klassen I–IV werden weiter geteilt nach der Zahl und Natur der asymmetrischen Atome wie folgt:

A_n Das Molekül enthält n asymmetrische Atome, von denen jedes an nur ein anderes Kohlenstoffatom gebunden ist.

B_n Das Molekül enthält n asymmetrische Atome, von denen jedes an zwei andere Kohlenstoffatome gebunden ist.

C_n Das Molekül enthält n asymmetrische Atome, von denen jedes an drei andere Kohlenstoffatome gebunden ist.

D_n Das Molekül enthält n asymmetrische Atome, von denen jedes an vier andere Kohlenstoffatome gebunden ist.

Für Stoffe die in zwei oder mehr der obigen Unterabteilungen fallen, erhält die höhere Abteilung (in der Reihenfolge D, C, B, A) bei der Entscheidung der Anordnung den Vorzug. Innerhalb einer Unterabteilung erfolgt die Anordnung entsprechend dem Werte von n in der Reihenfolge 1, 2, 3, usw.

ZEICHEN UND ABKÜRZUNGEN

t	Temperatur in Celsiusgraden (°C).
λ	Lichtwellenlänge ausgedrückt in Ångstrom Einheiten, d.h., in Zehnteln eines Millimikrons ($\frac{1}{10}\mu\mu$), wenn nicht anders angegeben.
D	Wellenlänge 5893 Å.
α_λ^t	Beobachtete Drehung bei den gegebenen Werten für t.
$[\alpha]_\lambda^t$	Spezifische Drehung bei den gegebenen Werten für t.
$[M]_\lambda^t$	Molekulare Drehung bei den gegebenen Werten für $t (= M \times [\alpha]_\lambda^t/100)$.
C	Konzentration in Gramm pro 100 cm³ Lösung.
%	Konzentration in Gramm pro 100 Gramm Lösung (= Gew. %). (Werte in Kursivschrift.)
d	d_4^t = Dichte bei dem gegebenen Wert für t (bezogen auf Wasser bei 4°C, wenn nicht anders angegeben).
2% NaOH (usw.)	2%-ige Lösung von NaOH in Wasser.
2% NaOH MeOH	2%-ige Lösung von NaOH in Methylalkohol.
M	Mole
N NaOH	Normale wässerige Lösung von NaOH (= 1 Äquivalent/Liter).

DISPOSIZIONE

La disposizione è fatta secondo classi definite come segue:

Composti del carbonio

I. Nessuno degli atomi di carbonio asimmetrici fa parte di un anello.

II. Almeno un atomo di carbonio asimmetrico fa parte di un anello.

III. Il composto contiene nessuno atomo asimmetrico di carbonio o contiene almeno un atomo asimmetrico o dissimmetrico diverso dal carbonio.

IV. Sostanze di struttura sconosciuta, incerta o complessa.

Le classi I–IV sono suddivise secondo il numero e la natura degli atomi asimmetrici nella maniera seguente:

A_n La molecola contiene n atomi asimmetrici i quali sono attaccati ciascuno a un altro atomo di carbonio soltanto.

B_n La molecola contiene n atomi asimmetrici i quali sono attaccati ciascuno a due altri atomi di carbonio.

C_n La molecola contiene n atomi asimmetrici i quali sono attaccati ciascuno a tre altri atomi di carbonio.

D_n La molecola contiene n atomi asimmetrici che sono attaccati ciascuno a quattro atomi di carbonio.

Per le sostanze che rientrano in due o più delle suddivisioni indicate, la divisione più alta (nell'ordine D, C, B, A) ha la preferenza nel decidere la disposizione. Entro ciascuna suddivisione la disposizione è d'accordo con il valore di n nell'ordine 1, 2, 3, ecc.

SIMBOLI ED ABBREVIAZIONI

t	Temperatura in gradi centigradi (°C).
λ	Lunghezza d'onda della luce espressa in unità Ångstrom, *i.e.*, in decimi di millimicron ($\frac{1}{10}\mu\mu$) tranne che non sia altrimenti indicato.
D	Una lunghezza d'onda di 5893 Å.
α_λ^t	Rotazione osservata ai valori di t indicati.
$[\alpha]_\lambda^t$	Rotazione specifica ai valori di t indicati.
$[M]_\lambda^t$	Rotazione molecolare ai valori dati per $t (= M \times [\alpha]_\lambda^t/100)$.
C	Concentrazione in grammi per 100 cm³ di soluzione.
%	Concentrazione in grammi per 100 grammi di soluzione (= % in peso). (Valori scritti in caratteri italici.)
d	d_4^t = densità al valore di t indicato, riferita all'acqua a 4°C salvo che non sia indicato altrimenti.
2% NaOH (ecc.)	2% di soluzione di NaOH in acqua.
2% NaOH MeOH	2% di soluzione di NaOH in alcool metilico.
M	Moli.
N NaOH	Soluzione acquosa normale di NaOH (=1 equivalente/litro).

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* For further data on these compounds at various temperatures, with other wave lengths, and in various solvents, *see* the forthcoming article by Professor Lowry, Miscellaneous Publications, Bureau of Standards, No. 118, 1931.

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* For further data on these compounds at various temperatures, with other wave lengths, and in various solvents, *see* the forthcoming article by Professor Lowry, Miscellaneous Publications, Bureau of Standards, No. 118, 1931.

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* For further data on these compounds at various temperatures, with other wave lengths, and in various solvents, *see* the forthcoming article by Professor Lowry, Miscellaneous Publications, Bureau of Standards, No. 118, 1931.

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* For further data on these compounds at various temperatures, with other wave lengths, and in various solvents, *see* the forthcoming article by Professor Lowry, Miscellaneous Publications, Bureau of Standards, No. 118, 1931.

Class I. ORGANIC SUBSTANCES, THE ASYMMETRIC CARBON ATOMS OF WHICH DO NOT FORM PART OF A RING

IB_1. The Molecule Contains One Asymmetric Atom Attached to Two Other Carbon Atoms

SIMPLE HALIDES

Formula	Name	d_4^{20}	t, °C	$[\alpha]_D$	Lit.
C_4H_9I	*l*-β-Iodobutane	1.5970	17	−31.98	(1619)
$C_5H_{11}I$	*l*-β-Iodopentane	1.5067	17	−37.15	(1619)
$C_6H_{13}I$	*l*-β-Iodohexane	1.4354	17	−38.35	(1619)
C_8H_9Cl	*l*-α-Chloroethylbenzene	1.0642	17	−5.80	(1619)
$C_8H_{17}Br$	*d*-β-Bromooctane	1.0895	17	+27.53	(1619)
	l-β-Bromooctane		4	−31.07	(1619)
		$1.0927_4^{13.8}$	13.1	−30.33	
		1.0914_4^{17}	17	−27.47	
		1.0805_4^{26}	30	−29.05	
		1.0688_4^{37}	37	−28.62	
		1.0532_4^{53}	50	−27.81	
			92	−25.18	
$C_8H_{17}Cl$	*l*-β-Chlorooctane	0.8628	17	−20.44	(1619)
	d-β-Chlorooctane	0.8658	17	+20.40	(1619)
$C_8H_{17}I$	*l*-β-Iodooctane	1.3299	17	−40.56	(1619)
	d-β-Iodooctane	1.3314	17	+39.82	(1619)
$C_9H_{11}Cl$	*l*-α-Chloropropylbenzene	1.0430	17	−3.87	(1619)
	d-α-Chloropropylbenzene	1.0429	17	+3.79	(1619)
$C_9H_{19}Br$	*l*-γ-Bromononane	1.0897	17	−13.39	(1619)
	d-γ-Bromononane	1.0900	17	+12.90	(1619)
$C_9H_{19}Cl$	*l*-γ-Chlorononane	0.8540	17	−8.03	(1619)
	d-γ-Chlorononane	0.8588	17	+7.71	(1619)
$C_9H_{19}I$	*l*-γ-Iodononane	1.2873	17	−17.50	(1619)
	d-γ-Iodononane	1.2940	17	+17.65	(1619)

ALCOHOLS

MONOHYDROXY ALCOHOLS, THIOLS AND THEIR ESTERS

Methyl carbinols, RCH_3CHOH (1619); *cf.* (812)

Formula	R	$[\alpha]_D^{20}$
$C_4H_{10}O$	Ethyl	13.87
$C_5H_{12}O$	*n*-Propyl	13.70
$C_6H_{14}O$	*n*-Butyl	11.57
$C_7H_{16}O$	*n*-Amyl	10.32
$C_8H_{18}O$	*n*-Hexyl	9.76
$C_9H_{20}O$	*n*-Heptyl	8.99
$C_{10}H_{22}O$	*n*-Octyl	8.68
$C_{11}H_{24}O$	*n*-Nonyl	8.13
$C_{12}H_{26}O$	*n*-Decyl	7.78
$C_{13}H_{28}O$	*n*-Undecyl	7.22

Ethyl carbinols, RC_2H_5CHOH (1622); *cf.* (1305)

$C_4H_{10}O$	Methyl	13.87
$C_6H_{14}O$	Propyl	1.97
$C_7H_{16}O$	Butyl	8.13
$C_8H_{18}O$	Amyl	8.22
$C_9H_{20}O$	Hexyl	7.38
$C_{10}H_{22}O$	Heptyl	6.68
$C_{11}H_{24}O$	Octyl	6.25
$C_{12}H_{26}O$	Nonyl	5.97
$C_{13}H_{28}O$	Decyl	6.23
$C_{14}H_{30}O$	Undecyl	5.87
$C_{15}H_{32}O$	Dodecyl	5.53
$C_{16}H_{34}O$	Tridecyl	5.11
$C_{18}H_{38}O$	Pentadecyl	4.77

Isopropyl carbinols, RC_3H_7CHOH (1305, 1620)

Formula	R	$[\alpha]_D^{20}$
$C_5H_{12}O$	Methyl	4.85
$C_6H_{14}O$	Ethyl	15.06
$C_7H_{16}O$	*n*-Propyl	21.25
$C_8H_{18}O$	*n*-Butyl	25.64
$C_9H_{20}O$	*n*-Amyl	22.84
$C_{10}H_{22}O$	*n*-Hexyl	21.46
$C_{12}H_{26}O$	*n*-Octyl	18.55
$C_{14}H_{30}O$	*n*-Decyl	16.15

Other carbinols (1624); *cf.* (1305)

Formula	Name	$[\alpha]_D^{20}$
$C_6H_{14}O$	*d*-Methyl *tert.*-butyl	7.71
$C_8H_{10}O$	*d*-Methyl phenyl	41.77
$C_9H_{12}O$	*l*-Ethyl phenyl	−25.86
$C_9H_{12}O$	*d*-Methyl benzyl	26.55
$C_{10}H_{14}O$	*l*-Methyl β-phenylethyl	−14.74
$C_{12}H_{12}O$	*l*-Methyl α-naphthyl	−14.53
$C_{17}H_{22}O$	*d*-*n*-Hexyl α-naphthyl	− 1.51

Ethers of *d*-Benzylmethyl carbinol, $C_7H_7(CH_3)CHOR$ (1617)

Formula	R	$[\alpha]_D^{20}$
$C_{14}H_{22}O$	*n*-Amyl	22.75
$C_{15}H_{24}O$	*n*-Hexyl	22.83
$C_{18}H_{30}O$	*n*-Nonyl	20.78

Methyl alkyl carbinyl esters (1623, 1625)

d-β-Butyl derivatives

Formula	Ester	$[\alpha]_D^{20}$
$C_5H_{10}O_2$	Formate	18.74
$C_6H_{12}O_2$	Acetate	25.43
$C_7H_{14}O_2$	Propionate	23.85
$C_8H_{16}O_2$	*n*-Butyrate	21.97
$C_9H_{18}O_2$	*n*-Valerate	20.72
$C_{10}H_{20}O_2$	*n*-Hexoate	18.66
$C_{11}H_{22}O_2$	*n*-Heptoate	17.37

d-β-Butyl derivatives.—(Continued)

Formula	Ester	$[\alpha]_D^{20}$
$C_{12}H_{24}O_2$	*n*-Octoate	16.14
$C_{13}H_{26}O_2$	*n*-Nonoate	15.03
$C_{15}H_{30}O_2$	*n*-Undecoate	13.42
$C_{16}H_{32}O_2$	*n*-Dodecoate	12.69
$C_{18}H_{36}O_2$	*n*-Myristate	11.34
$C_{20}H_{40}O_2$	Palmitate	10.25
$C_{22}H_{44}O_2$	Stearate	9.39

d-β-Amyl derivatives

Formula	Ester	$[\alpha]_D^{20}$
$C_7H_{14}O_2$	Acetate	17.16
$C_8H_{16}O_2$	Propionate	16.43
$C_9H_{18}O_2$	*n*-Butyrate	15.77
$C_{10}H_{20}O_2$	*n*-Valerate	16.01
$C_{17}H_{34}O_2$	*n*-Dodecoate	10.44

d-β-Hexyl derivatives

Formula	Ester	$[\alpha]_D^{20}$
$C_8H_{16}O_2$	Acetate	10.13
$C_9H_{18}O_2$	Propionate	9.76
$C_{10}H_{20}O_2$	*n*-Butyrate	10.83
$C_{11}H_{22}O_2$	*n*-Valerate	11.16
$C_{12}H_{24}O_2$	*n*-Hexoate	10.84
$C_{13}H_{26}O_2$	*n*-Heptoate	10.36
$C_{15}H_{30}O_2$	*n*-Nonoate	9.38
$C_{17}H_{34}O_2$	*n*-Undecoate	8.35
$C_{18}H_{36}O_2$	*n*-Dodecoate	7.99
$C_{20}H_{40}O_2$	*n*-Myristate	7.40
$C_{22}H_{44}O_2$	Palmitate	6.87
$C_{24}H_{48}O_2$	Stearate	6.16

d-β-Heptyl derivatives

Formula	Ester	$[\alpha]_D^{20}$
$C_9H_{18}O_2$	Acetate	8.23
$C_{10}H_{20}O_2$	Propionate	8.37
$C_{11}H_{22}O_2$	*n*-Butyrate	10.16
$C_{12}H_{24}O_2$	*n*-Valerate	10.26
$C_{13}H_{26}O_2$	*n*-Hexoate	9.97
$C_{14}H_{28}O_2$	*n*-Heptoate	9.53
$C_{15}H_{30}O_2$	*n*-Octoate	9.07
$C_{16}H_{32}O_2$	*n*-Nonoate	8.70
$C_{18}H_{36}O_2$	*n*-Undecoate	7.96
$C_{19}H_{38}O_2$	*n*-Dodecoate	7.58
$C_{21}H_{42}O_2$	*n*-Myristate	6.91
$C_{23}H_{46}O_2$	Palmitate	6.53
$C_{25}H_{50}O_2$	Stearate	6.06

d-β-Octyl derivatives

Formula	Ester	$[\alpha]_D^{20}$
$C_9H_{18}O_2$	Formate	−4.16
$C_{10}H_{20}O_2$	Acetate	6.84
$C_{11}H_{22}O_2$	Propionate	6.98
$C_{12}H_{24}O_2$	*n*-Butyrate	8.95
$C_{13}H_{26}O_2$	*n*-Valerate	9.16
$C_{14}H_{28}O_2$	*n*-Hexoate	8.96
$C_{15}H_{30}O_2$	*n*-Heptoate	8.59
$C_{16}H_{32}O_2$	*n*-Octoate	8.25
$C_{17}H_{34}O_2$	*n*-Nonoate	7.96
$C_{19}H_{38}O_2$	*n*-Undecoate	7.35
$C_{20}H_{40}O_2$	*n*-Dodecoate	7.00
$C_{22}H_{44}O_2$	*n*-Myristate	6.59
$C_{24}H_{48}O_2$	Palmitate	6.14
$C_{26}H_{52}O_2$	Stearate	5.71

d-β-Nonyl derivatives

Formula	Ester	$[\alpha]_D^{20}$
$C_{11}H_{22}O_2$	Acetate	6.21
$C_{21}H_{42}O_2$	*n*-Dodecoate	6.71

d-β-Decyl derivatives

Formula	Ester	$[\alpha]_D^{20}$
$C_{12}H_{24}O_2$	Acetate	5.64
$C_{22}H_{44}O_2$	*n*-Dodecoate	6.41

d-β-Undecyl derivatives

Formula	Ester	$[\alpha]_D^{20}$
$C_{13}H_{26}O_2$	Acetate	5.27
$C_{14}H_{28}O_2$	Propionate	5.15
$C_{15}H_{30}O_2$	*n*-Butyrate	7.31
$C_{16}H_{32}O_2$	*n*-Valerate	7.46
$C_{17}H_{34}O_2$	*n*-Hexoate	7.37
$C_{18}H_{36}O_2$	*n*-Heptoate	7.17
$C_{20}H_{40}O_2$	*n*-Nonoate	6.81
$C_{22}H_{44}O_2$	*n*-Undecoate	6.30
$C_{23}H_{46}O_2$	*n*-Dodecoate	6.19
$C_{25}H_{50}O_2$	*n*-Myristate	5.72

d-β-Dodecyl derivatives

Formula	Ester	$[\alpha]_D^{20}$
$C_{24}H_{48}O_2$	*n*-Dodecoate	5.99

d-β-Tridecyl derivatives

Formula	Ester	$[\alpha]_D^{20}$
$C_{15}H_{30}O_2$	Acetate	4.63
$C_{25}H_{50}O_2$	*n*-Dodecoate	5.87

d-γ-Nonyl esters **(1051, 1625)**

Formula	Ester	$[\alpha]_D^{20}$
$C_{10}H_{20}O_2$	Formate	−11.28
$C_{11}H_{22}O_2$	Acetate	− 5.21
$C_{12}H_{24}O_2$	Propionate	− 5.87
$C_{13}H_{26}O_2$	*n*-Butyrate	− 3.38
$C_{14}H_{28}O_2$	Valerate	− 3.12
$C_{15}H_{30}O_2$	*n*-Hexoate	− 2.66
$C_{16}H_{32}O_2$	*n*-Heptoate	− 2.36
$C_{17}H_{34}O_2$	*n*-Octoate	− 2.10
$C_{18}H_{36}O_2$	*n*-Nonoate	− 1.94
$C_{19}H_{38}O_2$	*n*-Decoate	− 1.90
$C_{20}H_{40}O_2$	*n*-Undecoate	− 1.83
$C_{21}H_{42}O_2$	*n*-Dodecoate	− 1.63
$C_{23}H_{46}O_2$	*n*-Myristate	− 1.55
$C_{25}H_{50}O_2$	Palmitate	− 1.49
$C_{27}H_{54}O_2$	Stearate	− 1.49

Acetic acid esters, CH_3COOR **(1051)**

Formula	R	$[\alpha]_D^{20}$
$C_8H_{16}O_2$	*d-γ*-Hexyl	0.55
$C_9H_{18}O_2$	*d-γ*-Heptyl	−4.68
$C_{10}H_{20}O_2$	*d-γ*-Octyl	−4.30
$C_{12}H_{24}O_2$	*l-γ*-Decyl	4.48
$C_{13}H_{26}O_2$	*l-γ*-Undecyl	4.40
$C_{14}H_{28}O_2$	*l-γ*-Dodecyl	3.68
$C_{15}H_{30}O_2$	*l-γ*-Tridecyl	3.83
$C_{16}H_{32}O_2$	*l-γ*-Tetradecyl	3.69
$C_{17}H_{34}O_2$	*l-γ*-Pentadecyl	3.68
$C_{18}H_{36}O_2$	*l-γ*-Hexadecyl	3.19
$C_{20}H_{40}O_2$	*l-γ*-Octadecyl	2.98

Esters of methyl benzyl carbinol **(1052.5)**

Formula	Ester	$[\alpha]_D^{20}$
$C_{11}H_{14}O_2$	Acetate	6.41
$C_{12}H_{16}O_2$	Propionate	4.81
$C_{13}H_{18}O_2$	*n*-Butyrate	8.48
$C_{14}H_{20}O_2$	*n*-Valerate	10.76
$C_{15}H_{22}O_2$	*n*-Hexoate	10.46
$C_{16}H_{24}O_2$	*n*-Heptoate	10.69
$C_{17}H_{26}O_2$	*n*-Octoate	10.67
$C_{18}H_{28}O_2$	*n*-Nonoate	10.50
$C_{19}H_{30}O_2$	*n*-Decoate	10.13
$C_{20}H_{32}O_2$	*n*-Undecoate	9.92
$C_{21}H_{34}O_2$	*n*-Dodecoate	9.66
$C_{24}H_{38}O_2$	Myristate	9.22
$C_{26}H_{42}O_2$	Palmitate	8.44
$C_{28}H_{46}O_2$	Stearate	7.92

ALCOHOLS.—(*Continued*)

Esters of *d*-α-naphthyl-*n*-hexyl carbinol (**1053**)

Formula	Ester	$[\alpha]_D^{20}$
$C_{19}H_{24}O_2$	Acetate	23.85
$C_{20}H_{26}O_2$	Propionate	28.59
$C_{21}H_{28}O_2$	*n*-Butyrate	27.02
$C_{22}H_{30}O_2$	*n*-Valerate	22.23
$C_{23}H_{32}O_2$	*n*-Hexoate	21.12
$C_{24}H_{34}O_2$	*n*-Heptoate	19.63
$C_{25}H_{36}O_2$	*n*-Octoate	21.13
$C_{26}H_{38}O_2$	*n*-Nonoate	19.06
$C_{27}H_{40}O_2$	*n*-Decoate	17.13
$C_{28}H_{42}O_2$	*n*-Undecoate	16.44

Esters of benzoic acid and naphthoic acids with secondary alcohols

Benzoic acid esters (**1056**)

Formula	Ester	$[\alpha]_D^{20}$
$C_{11}H_{14}O_2$	*d*-β-Butyl	39.23
$C_{13}H_{18}O_2$	*d*-β-Hexyl	35.38
$C_{15}H_{22}O_2$	*d*-β-Octyl	33.27
$C_{16}H_{16}O_2$	*d*-Benzyl methyl carbinyl	65.07
$C_{16}H_{24}O_2$	*d*-γ-Nonyl	6.84
$C_{18}H_{28}O_2$	*d*-β-Undecyl	27.55

α-Naphthoic acid esters (**1056**)

Formula	Ester	$[\alpha]_D^{20}$
$C_{15}H_{16}O_2$	*d*-β-Butyl	28.40
$C_{17}H_{20}O_2$	*d*-β-Hexyl	5.87
$C_{18}H_{22}O_2$	*d*-β-Heptyl	3.99
$C_{19}H_{24}O_2$	*d*-β-Octyl	1.67
$C_{20}H_{18}O_2$	*d*-Benzyl methyl carbinyl	29.10
$C_{20}H_{26}O_2$	*d*-γ-Nonyl	−22.23
$C_{21}H_{28}O_2$	*d*-β-Decyl	1.41
$C_{22}H_{30}O_2$	*d*-β-Undecyl	1.63

β-Naphthoic acid esters (**1056**)

Formula	Ester	$[\alpha]_D^{20}$
$C_{15}H_{16}O_2$	*d*-β-Butyl	50.04
$C_{17}H_{20}O_2$	*d*-β-Hexyl	57.11
$C_{19}H_{24}O_2$	*d*-β-Octyl	56.25
$C_{20}H_{18}O_2$	*d*-Benzyl methyl carbinyl	122.83
$C_{20}H_{26}O_2$	*d*-γ-Nonyl	19.14
$C_{22}H_{30}O_2$	*d*-β-Undecyl	50.03

Formula	Name	Solvent	*d* or *C*	*t*, °C	$[\alpha]_D$	Lit.
$C_4H_{10}O$	*sec.*-Butyl alcohol		0.8034	25	13.11	(**2185**)
$C_4H_{10}S$	*sec.*-Butylmercaptan	EtOH	20		>12.45	(**631**)
$C_{13}H_{13}NO$	*l*-α-[β-Hydroxy-β-phenylethyl] pyridine $NC_5H_4.CH_2.CHOH.C_6H_5$	$CHCl_3$	13.2	25	−36.44	(**1267**)
$C_{17}H_{22}O_2$	*d*-β-Octyl β-phenylpropiolate				35.08	(**908**)
		$CHCl_3$	2.5	22	30.88	
		C_6H_6	2.5	22	35.12	
$C_{17}H_{24}O_2$	*d*-β-Octyl β-cinnamate			22	35.32	(**908**)
		$CHCl_3$	2.5	22	30.40	
		C_6H_6	2.5	22	33.04	
$C_{17}H_{26}O_2$	*d*-β-Octyl β-phenylpropionate			22	11.92	(**908**)
		$CHCl_3$	2.5	22	11.52	
		C_6H_6	2.5	22	6.00	
	KETO ALCOHOLS					
$C_{14}H_{12}O_2$	*d*-Benzoin	Me_2CO	0.413	11.5	120.5	(**2214**)
	l-Benzoin	Me_2CO	0.923	10.5	−118.6	(**1354**)
	l-Benzoin	EtOH	0.923	10.5	−118.6	(**2214**)
$C_{14}H_{13}NO_2$	*l*-Benzoin α-oxime	$CHCl_3$	0.858	24	−3.2	(**2214**)
		EtOH	0.965	23	4.4	
		$C_6H_5CO_2Et$	0.472	23.3	37.0	
		Me_2CO	0.707	15	18.0	
$C_{15}H_{14}O_2$	*l*-Benzoin methyl ether	EtOH	0.586	11	−94.3	(**2214**)
		$CHCl_3$	2.111	12	−88.2	
		C_7H_{16}	5.65	11.5	147.8	
		C_6H_6	0.643	15	50.9	
$C_{15}H_{14}O_2$	*d*-Benzoylbenzylcarbinol	Me_2CO	1.23	17.5	12.6	(**1344**)
$C_{16}H_{14}O_3$	Acetyl-*l*-benzoin	$CHCl_3$	0.724	14.5	−217.9	(**2214**)
$C_{21}H_{17}NO_3$	Carbanilido-*l*-benzoin	C_6H_6	0.802	18	−291.9	(**2214**)
	$C_6H_5.CO.CH(C_6H_5).O.CO.NH.C_6H_5$	Me_2CO	0.653	21	−214.8	
	POLYHYDROXY ALCOHOLS AND DERIVATIVES					
$C_5H_{11}NO_4$	Pentane-3, 4, 5-triolal oxime(Class IB_2) $(HO.CH_2(CHOH)_2.CH_2.CH:NOH)$	H_2O	4.2		10.6	(**1067**)
	Pentane-1, 4, 5-triol-3-one oxime $(HO.CH_2.CHOH.C(NOH)CH_2.CH_2.OH)$	H_2O	3.28		11.8	(**1067**)
$C_{20}H_{18}O_2$	*d*-α, β-Dihydroxy-α, β, β-triphenylethane	$CHCl_3$	1.32		−228	(**1338**)
$C_{21}H_{20}O_2$	*l*-β-Hydroxy-α-methoxy-α, β, β-triphenylethane	Me_2CO	5.428	12	−185.3	(**1355**)
		$CHCl_3$	4.579	13	−235	
		C_6H_6	3.667	9	−294.5	
		EtOH	1.0176	8	−166.3	
$C_{20}H_{20}O_6$	Cubebin $(C_6H_8(OH)_2(C_6H_4:O_2:CH_2)_2)$	$CHCl_3$		25	−45.45	(**1366**)

AMINES

MONOAMINES

sec.-Butylamine and derivatives

Formula	Name	Solvent	*d* or *C*	*t*, °C	$[\alpha]_D$	Lit.
$C_4H_{11}N$	*d-sec.*-Butylamine		0.724	20	7.44	(2014)
$C_4H_{12}ClN$	*d-sec.*-Butylamine hydrochloride	H_2O	14.03	20	−1.13	(2014)
	l-sec.-Butylamine hydrochloride	H_2O	13.5	20	+1.12	(2014)
$C_5H_{12}N_2S$	*d-sec.*-Butylthiocarbamide		0.943	20	61.88	
$C_9H_{20}N_2O$	*d*-Di-*sec.*-butylcarbamide	EtOH	2.46	20	39.71	(698)
	α-Phenylethylamine and derivatives					
$C_8H_{11}N$	*d-α*-Phenylethylamine		0.95	15	40.27	(1282); *cf.* (1380)
	l-α-Phenylethylamine		0.952	20	−39.9	(1557); *cf.* (916)
		EtOH	3.25	20	−31.5	
$C_8H_{12}ClN$	*l-α*-Phenylethylamine hydrochloride	H_2O	4.55	20	−5.3	(1557)
		EtOH	1.80	20	−5.0	
$C_9H_{12}N_2O$	*d-α*-Phenylethylcarbamide	EtOH	4.035		46.2	(1380)
	l-α-Phenylethylcarbamide	EtOH	14.06		−43.6	(1282)
			3.72		−52.1	
$C_9H_{13}N$	*d-α-p*-Tolylethylamine		0.9366	20	36.57	(1985)
		EtOH	2.0	20	32.1	(1986)
		EtOH	1.0	20	32.9	
		AcOEt	2.6	20	36.1	
$C_{10}H_{14}N_2O$	*l-p*-Tolylethylcarbamide	EtOH	1.53	20	−35.9	(1986)
		EtOH	0.766	20	−37.5	
		AcOEt	1.67	20	−31.3	
		AcOEt	0.835	20	−30.3	
		Me_2CO	1.73	20	−22.0	(1986)
$C_{10}H_{15}N$	*l-p*-Ethylphenylethylamine			20	−31.7	(1986)
		EtOH	2.27	20	−26.0	
		AcOEt	2.00	20	−27.5	
		AcOEt	1.00	20	−28.3	
$C_{10}H_{15}N$	*N*-Ethyl-*l-α*-phenylethylamine		0.907	20	−61.2	(1557)
		EtOH	3.91	20	−53.2	
$C_{10}H_{16}BrN$	*N*-Ethyl-*l-α*-phenylethylamine hydrobromide	H_2O	2.79	20	−10.3	(1557)
		EtOH	4.50	20	−17.0	
$C_{10}H_{16}ClN$	*N*-Ethyl-*l-α*-phenylethylamine hydrochloride	H_2O	2.50	20	−12.2	(1557)
		EtOH	2.82	20	−21.4	
$C_{11}H_{16}N_2O$	*N*-Ethyl-*l-α*-phenylethylcarbamide	EtOH	1.53	20	−50.4	(1557)
		EtOH	0.765	20	−51.5	
		AcOEt	1.66	20	−41.8	
		AcOEt	0.834	20	−42.8	
		Me_2CO	2.00	20	−29.2	
		Me_2CO	1.00	20	−30.1	
$C_{11}H_{16}N_2S$	*N*-Dimethyl-*l-α*-phenylethylthiocarbamide	EtOH	2.0	20	7.1	(1986)
		AcOEt	1.53	20	31.7	
		AcOEt	0.765	20	32.8	
		Me_2CO	1.66	20	39.6	
$C_{11}H_{17}N$	*N*-Methylethyl-*l-α*-phenylethylamine		0.904	20	−39.2	(1557)
		EtOH	2.84	20	−36.7	
$C_{11}H_{17}N$	*N*-Propyl-*l-α*-phenylethylamine		0.896	20	−69.1	(1557)
		EtOH	2.76	20	−62.1	
$C_{11}H_{18}BrN$	*N*-Propyl-*l-α*-phenylethylamine hydrobromide	H_2O	2.63	20	−20.4	
		EtOH	3.05	20	−26.3	
$C_{11}H_{18}ClN$	*N*-Propyl-*l-α*-phenylethylamine hydrochloride	H_2O	1.90	20	−24.3	(1557)
		EtOH	1.90	20	−35.4	
$C_{13}H_{20}N_2S$	*N*-Diethyl-*d-α*-phenylethylthiocarbamide	Me_2CO	2.0	20	−44.9	(1986)
			4.0	20	−43.9	
	N-Diethyl-*l-α*-phenylethylthiocarbamide	EtOH	2.33	20	7.6	(1986)
		AcOEt	1.67	20	40.7	
		Me_2CO	1.53	20	44.1	
$C_{15}H_{15}NO$	Benzoyl-*l-α*-phenylethylamine					(1986)
$C_{15}H_{15}NO_2$	*N-p*-Hydroxybenzoyl *d-α*-phenylethylamine	$CHCl_3$	0.747		54.6	(1454)
$C_{15}H_{17}N$	*N*-Benzyl-*l-α*-phenylethylamine		1.008	20	−40.1	(1557)
		EtOH	3.74	20	−58.4	

AMINES.—(*Continued*)

Formula	Name	Solvent	*d* or *C*	*t*, °C	$[\alpha]_D$	Lit.
$C_{15}H_{18}ClN$	*N*-Benzyl-*l*-α-phenylethylamine hydrochloride	H_2O	2.80	20	−9.1	(**1557**)
		EtOH	3.48	20	−18.5	
$C_{15}H_{21}NO_5$	*l*-Quinic *l*-α-phenylethylamide	Py	6.692	20	−92.1	(**1380**)
$C_{17}H_{21}N$	*N*-Ethylbenzyl-*l*-α-phenylethylamine	EtOH	1.87	20	−31.5	(**1557**)
		EtOH	1.98	20	−12.6	
$C_{17}H_{22}Cl_2N_2S$	*d*-Diphenylethylthiocarbamide dihydrochloride ($CS(NH.CHCH_3.C_6H_5)_2$)	EtOH	*1%*		22.5	(**1284**)
	l-Diphenylethylthiocarbamide dihydrochloride	EtOH	*1%*		−22.1	(**1284**)
$C_{18}H_{22}N_2S$	Methyl-*l*-phenylethylimidophenylethylthiocarbamate ($C_6H_5.CHCH_3.N{:}C(SCH_3).NH.$-$CHCH_3.C_6H_5$)	EtOH	4.15		96	(**1532**)
$C_{18}H_{24}IN$	*d*-Methylethylbenzyl-α-phenylethylammonium iodide	H_2O	4.38	20	24.9	(**1557**)
$C_{18}H_{25}NO$	*d*-Methylethylbenzyl-α-phenylethylammonium hydroxide	EtOH	4.54		26.0	(**1557**)
$C_{18}H_{28}N_2O_4S$	*d*-*p*-Tolylethylamine sulfate	H_2O	3.2	20	3.4	(**1986**)
$C_{20}H_{28}N_2O_4$	*d*-*p*-Tolylethylamine oxalate	H_2O	1.5	20	4.0	(**1986**)
$C_{20}H_{32}N_2O_4S$	*l*-*p*-Ethylphenylethylamine sulfate	H_2O	3.34	20	−6.3	(**1986**)
		H_2O	1.67	20	−14.8	
		H_2O	0.80	20	−17.8	
		H_2O	0.41	20	−20.6	
$C_{22}H_{23}N$	*N*-Dibenzyl-*l*-α-phenylethylamine	EtOH	1.76	20	−97.8	(**1557**)
$C_{22}H_{32}N_2O_4$	*l*-*p*-Ethylphenylethylamine oxalate	H_2O	8.67	20	−14.4	(**1986**)
		H_2O	4.34	20	−32.7	
		H_2O	2.17	20	−30.8	

d-Aminobenzyl-β-naphthol and derivatives (**136, 138, 139, 141**)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	$M[_D]$
	$R = HO.C_{10}H_6.CH(C_6H_5).NH_2$					
$C_{17}H_{15}NO$	*d*-Aminobenzyl-β-naphthol (≡R)	C_6H_6	4.76	18	+58.84	
	l-Aminobenzyl-β-naphthol (≡R)	C_6H_6	5		−58.96	
$C_{17}H_{16}ClNO$	*d*-Aminobenzyl-β-naphthol hydrochloride	EtOH		18	+52.89	
	l-Aminobenzyl-β-naphthol hydrochloride	EtOH	4.76	18	−52.51	
$C_{24}H_{17}Br_2NO_2$	3, 5-Dibromo-hydroxybenzylidene-R	C_6H_6	*1.29*	14–15	+92.18	+471.0
$C_{24}H_{17}ClN_2O_3$	2-Chloro-5-nitrobenzylidene-R	C_6H_6	*1.87*	15–18	−98.9	−412.0
$C_{24}H_{17}Cl_2NO$	2, 5-Dichlorobenzylidene-R	C_6H_6	*0.978*	15–18	−59.7	−242.6
$C_{24}H_{18}BrNO_2$	3-Bromo-4-hydroxybenzylidene-R	C_6H_6	*0.885*	14–15	+150.1	+648.0
$C_{24}H_{18}BrNO_2$	5-Bromosalicylidene-R	C_6H_6	*1.31*	14–15	−76.37	−329.9
$C_{24}H_{18}ClNO$	*o*-Chlorobenzylidene-R	C_6H_6	*2.90*	15–18	−34.6	−128.4
	m-Chlorobenzylidene-R	C_6H_6	*0.995*	15–18	+68.9	+255.9
	p-Chlorobenzylidene-R	C_6H_6	*0.932*	15–18	+75.9	+282.2
$C_{24}H_{18}N_2O_3$	*o*-Nitrobenzylidene-R	C_6H_6	*2.09*	14–15	−259.36	−990.7
	m-Nitrobenzylidene-R	C_6H_6	*1.10*	14–15	+43.88	+167.6
	p-Nitrobenzylidene-R	C_6H_6	*1.53*	14–15	+54.29	+207.4
$C_{24}H_{18}N_2O_4$	5-Nitrosalicylidene-R	C_6H_6	*0.187*	14–15	−132.37	−526.8
	3-Nitrosalicylidene-R	C_6H_6	*0.232*	14–15	+38.83	+154.5
$C_{24}H_{19}NO$	Benzylidene-R	C_6H_6	*4.734*	20	110.7	
$C_{24}H_{19}NO_2$	*o*-Hydroxybenzylidene-R	C_6H_6	*6.238*	20	−15.7	
	m-Hydroxybenzylidene-R	C_6H_6	*0.990*	15–18	+102.7	+362.6
	p-Hydroxybenzylidene-R	C_6H_6	*0.985*	20	+297.3	+1049.5
$C_{24}H_{19}NO_3$	3, 4-Dihydroxybenzylidene-R	C_6H_6	*1.105*	20	+159.6	+588.8
$C_{25}H_{19}NO_3$	Piperonylidene-R	C_6H_6	*2.848*	20	+259.6	+989.0
$C_{25}H_{20}BrNO_2$	5-Bromomethylsalicylidene-R	C_6H_6	*4.12*	14–15	+39.45	+175.9
$C_{25}H_{20}N_2O_4$	3-Nitroanisylidene-R	C_6H_6	*0.729*	14–15	+135.83	+559.6
$C_{25}H_{21}NO$	*o*-Methylbenzylidene-R	C_6H_6	*0.906*	15–18	−93.01	−326.5
	m-Methylbenzylidene-R	C_6H_6	*2.127*	15–18	+143.73	+504.5
	p-Methylbenzylidene-R	C_6H_6	*2.004*	15–18	+196.1	+691.4
$C_{25}H_{21}NO_2$	2-Hydroxy-4-methylbenzylidene-R	C_6H_6	*3.05*	15–18	−18.6	−68.3

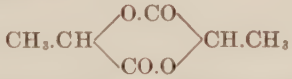
d-Aminobenzyl-β-naphthol and derivatives (136, 138, 139, 141).—(*Continued*)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	$M[_D]$
$C_{25}H_{21}NO_2$	*o*-Methoxybenzylidene-R	C_6H_6	*6.254*	20	+243.6	+894.0
	m-Methoxybenzylidene-R	C_6H_6	*1.09*	15–18	+139.7	+512.6
	p-Methoxybenzylidene-R	C_6H_6	*7.390*	20	+314.5	+1154.1
$C_{25}H_{21}NO_3$	3, 4-Dihydroxy-5-methylbenzylidene-R	C_6H_6	*4.096*	20	+318.5	
$C_{26}H_{19}ClN_2O_3$	α-Chloro-*o*-nitrocinnamylidene-R	C_6H_6	*1.425*	20	61.5	+272
$C_{26}H_{19}BrN_2O_3$	α-Bromo-*p*-nitrocinnamylidene-R	C_6H_6	*1.310*	10–12	+73.8	+359.0
$C_{26}H_{19}ClN_2O_3$	α-Chloro-*p*-nitrocinnamylidene-R	C_6H_6	*1.472*	10–12	+85.5	+378.0
$C_{26}H_{20}BrNO$	α-Bromocinnamylidene-R	C_6H_6	*1.031*	10–12	+146.0	+645.0
$C_{26}H_{20}ClNO$	α-Chlorocinnamylidene-R	C_6H_6	*0.918*	10–12	+199.5	+793.0
$C_{26}H_{20}N_2O_3$	*o*-Nitrocinnamylidene-R	C_6H_6	*2.380*	10–12	+350.1	+1428.0
	p-Nitrocinnamylidene-R	C_6H_6	*0.720*	10–12	+395.3	+1613.0
$C_{26}H_{21}NO$	Cinnamylidene-R	C_6H_6	*0.572*	10–12	+478.0	+1775.8
$C_{26}H_{23}NO_2$	2-Methoxy-4-methylbenzylidene-R	C_6H_6	*2.00*	15–18	+220.05	+838.4
$C_{26}H_{23}NO_3$	3, 4-Dimethoxybenzylidene-R	C_6H_6	*4.096*	20	+318.5	+1220.0
$C_{26}H_{24}N_2O$	*p*-Dimethylaminobenzylidene-R	C_6H_6	*0.994*	20	+704.2	+2676.0
$C_{27}H_{25}NO$	*p*-Isopropylbenzylidene-R	C_6H_6	*7.360*	20	+197.0	+746.5
$C_{27}H_{25}NO_4$	2, 4, 6-Trimethoxybenzylidene-R	C_6H_6	*0.869*	20	+421.9	+1801.9
$C_{28}H_{21}NO_2$	β-Hydroxynaphthylidene-R	C_6H_6	*1.054*	20	−232.3	−936.3
$C_{29}H_{23}NO_2$	β-Methoxynaphthylidene-R	C_6H_6	*2.585*	20	+133.42	+556.4

Diamines

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_3H_9BrN_2$	*d*-α, β-Diamino-γ-bromopropane	H_2O	*8.67*	18	5.20	(8)
$C_3H_{10}N_2$	*d*-Propylenediamine		0.8588	25	29.70	(322)
	l-Propylenediamine		0.863	25	−28.04	(322)
$C_9H_{30}CoN_6I_3$	Cobalt tri-*l*-propylenediamine iodide	H_2O	*3.38*	25	23.63	(323)
$C_3H_{11}Br_3N_2$	*d*-α, β-Diamino-γ-bromopropane dihydrobromide	H_2O	*7.50*	18	7.27	(8)
$C_3H_{12}Cl_2N_2$	*l*-Propylenediamine dihydrochloride	H_2O	*19.92*	25	−4.04	(322)
$C_4H_{12}N_2O$	*d*-α, β-Diamino-γ-methoxypropane	H_2O	*8.31*	18	8.19	(8)
$C_4H_{14}Br_2N_2O$	*d*-α, β-Diamino-γ-methoxypropane dihydrobromide	H_2O	*8.44*	18	9.04	(8)
	Hydroxyamines					
$C_9H_{13}NO_3$	*l*-Adrenaline	0.1*N* H_2SO_4	1	20	−53.3	(128)
	($C_6H_3(OH)_2.CHOH.CH_2NH.CH_3$)	$CHCl_3$	9.26		−15.12	(689)
	d-Adrenaline	0.32*N* HCl	*3.89*	19.8	51.88	(563)
$C_{21}H_{41}NO_3$	Diacetylhydroxyheptadecylamine	50% $CHCl_3$.MeOH	*18.0*	25	20.44	(1220.5)
	CARBOXYLIC ACIDS					
	Monohalogenomonocarboxylic Acids					
$C_3H_5BrO_2$	*l*-α-Bromopropionic acid		1.7084^{20}_{20}	20	−26.7	(554, 555); *cf.* (1764)
			1.705^{20}_{4}	20	−27	(1765)
$C_4H_7BrO_2$	Methyl *d*-α-bromopropionate		1.482^{17}_{4}		42.65	(2102)
$C_4H_7ClO_2$	*d*-β-Chlorobutyric acid	H_2O	*9.89*	20	49.8	(545)
		PhMe	*10.21*	20	46.6	
	Sodium salt	*N* NaOH	*9.10*	20	41.3	(545)
$C_4H_7ClO_2$	Methyl *d*-α-chloropropionate		1.1520^{20}_{4}		19.01	(2091)
$C_5H_9BrO_2$	Ethyl *l*-α-bromopropionate		1.386^{9}_{4}		−31.45	(2102)
$C_5H_9ClO_2$	Ethyl *d*-α-chloropropionate		1.0888^{20}_{4}		12.86	(2091)
$C_6H_{11}BrO_2$	*l*-α-Bromoisohexoic acid		1.358	20	−49.43	(495)
$C_6H_{11}BrO_2$	Propyl *d*-α-bromopropionate		1.315^{14}_{4}		−21.98	(2102)
$C_6H_{11}ClO_2$	Propyl *d*-α-chloropropionate		1.065^{6}_{4}		11.0	(2102)
$C_8H_7BrO_2$	*l*-Phenylbromoacetic acid	C_6H_6	4.10		−147.5	(1349); *cf.* (2090)
$C_8H_7ClO_2$	*l*-Phenylchloroacetic acid	C_6H_6	3.345	12	−191	(1332, 1333)
		$CHCl_3$	1.650	11.2	−159.4	
		EtOH	2.00	18	−155.8	(1346); *cf.* (2090)
$C_8H_{15}BrO_2$	Ethyl *l*-α-bromoisocaproate		1.22	20	−43.1	(1867)
$C_9H_9BrO_2$	*l*-α-Bromohydrocinnamic acid		1.48	20	−8.3	(495)
$C_9H_9ClO_2$	Methyl *l*-phenylchloroacetate		1.213	15	−86.7	(1330)
$C_{10}H_{11}ClO_2$	Ethyl *l*-phenylchloroacetate		1.162	16.4	−64.0	(1330)
$C_{11}H_{13}ClO_2$	*d*-Isopropylphenylchloroacetic acid	C_6H_6	3.0		23.3	(2090)

DIHALOGENOMONOCARBOXYLIC ACIDS AND THEIR DERIVATIVES

Formula	Name	Solvent	*d, C* or *%*	*t*, °C	$[\alpha]_D$	Lit.
$C_3H_4Br_2O_2$	*d*-α, β-Dibromopropionic acid	H_2O	*4.94*	18	13.76	(6)
		EtOH	*7.45*	18	6.42	
$C_4H_6Cl_2O_2$	Methyl α, β-dichloropropionate*			20	1.70	(658)
$C_5H_8Br_2O_2$	Ethyl *d*-α, β-dibromopropionate	EtOH	*1.08*	18	9.77	(6)
$C_5H_8Cl_2O_2$	Ethyl α, β-dichloropropionate*			20	−1.79	(658)
$C_7H_{12}Cl_2O_2$	Isobutyl α, β-dichloropropionate*			20	−3.62	(658)
$C_{10}H_{18}Cl_2O_2$	Heptyl α, β-dichloropropionate*			20	−1.73	(658)
	MONOHYDROXYMONOCARBOXYLIC ACIDS					
$C_3H_3O_3K$	Potassium *d*-glycidate	H_2O	*6.50*	18	30.16	(6)
	Lactic acid and derivatives (including thio-compounds)					
$C_3H_6O_2S$	*l*-Thiolactic acid		$1.193^{19.2}_{19.2}$	15	−45.47	(1283)
$C_3H_6O_3$	*d*-Lactic acid ($CH_3.CHOH.COOH$)	H_2O	10.46	15	3.82	(1019); *cf.* (924, 2201)
		H_2O	5.022	15	3.33	
		H_2O	2.511	15	2.67	
		H_2O	1.527	15	2.61	
	Calcium salt	H_2O	7.23		−3.87	(2201)
	Lithium salt	H_2O	*5*		−10.95	(924)
		H_2O	*12*		−12.28	(1019); *cf.* (924, 2201)
	Zinc salt + $2H_2O$	H_2O	5.0	15	−6.0	
		H_2O	2.5	15	−8.0	
		H_2O	1.25	15	−11.1	
		H_2O	0.512	15	−13.35	
$C_4H_8O_3$	*l*-Methoxypropionic acid	H_2O	13.47		−71.09	(1737)
	Calcium salt	H_2O	9.53		−38.09	(1737)
	Sodium salt	H_2O	16.53		−49.43	(1737)
$C_5H_{10}O_3$	Ethyl *l*-lactate; *cf.* (646, 1095)		1.030	19	14.52	(2102)
$C_5H_{10}O_3$	*d*-Ethoxypropionic acid	H_2O	29.37		56.96	(1737)
	Calcium salt	H_2O	26.87		38.40	(1737)
	Sodium salt	H_2O	17.96		48.09	(1737)
$C_6H_8O_4$	*d*-Lactide	C_6H_6	1.167	18	−298	(1020)
		C_6H_6	0.583	18	−280	
		C_6H_6	0.292	18	−246	
		H_2O	0.39		−8‡	
$C_6H_{10}O_4S$	*l*-Thiodilactylic acid ($S(CH.CH_3.COOH)_2$)	H_2O			−190	(1283)
$C_6H_{10}O_4S_2$	*d*-Dithiodilactylic acid ($S_2(CH.CH_3.COOH)_2$)	H_2O	6.4	15	429	(1283)
$C_6H_{12}O_3$	Propyl *d*-lactate		1.004	19	−17.06	(2102)
$C_6H_{12}O_3$	*d*-Propoxypropionic acid	H_2O	11.45		55.63	(1737)
	Calcium salt	H_2O	12.01		48.54	(1737)
	Sodium salt	H_2O	30.75		48.94	(1737)
$C_9H_9NO_5$	*l*-*m*-Nitrophenoxypropionic acid	EtOH	0.8	21	−51.87	(617)
	l-*p*-Nitrophenoxypropionic acid	EtOH	0.8	21	−53.7	
$C_{11}H_{11}NO_3$	*l*-Indol-3-lactic acid†	H_2O	*1.391*	20	−5.34	(411)
	β-Hydroxybutyric acid and salts					
$C_4H_8O_3$	*l*-β-Hydroxybutyric acid	H_2O	3.26	20	−24.8	(1325); *cf.* (374.5, 775, 1138.5, 1440.5, 1838.6)
		EtOH	8.21	18	−17.5	
	Magnesium salt	H_2O	14.39	13	−17.9	
		H_2O	2.30	13	−15.3	
	Potassium salt	H_2O	4.37	12	−12.3	
		H_2O	1.75	12	−11.9	
	Sodium salt	H_2O	8.52	15	−14.5	
		H_2O	1.36	17	−13.8	
	Zinc salt	H_2O	22.21	18	−17.9	
		H_2O	1.42	18	−14.2	
$C_4H_5Cl_3O_3$	*l*-γ, γ, γ-Trichloro-β-hydroxybutyric acid	EtOH	1.553	17	−29.6	(1345)
		EtOH	4.000	15.5	−30.1	
		Me_2CO	1.553	16.5	−22.5	
	Mandelic acid and derivatives					
$C_8H_8O_3$	*d*-Mandelic acid ($C_6H_5.CHOH.COOH$); *cf.* (1242, 1324.5, 1783.5, 2090, 2091)	H_2O	2.01		155.5	(404)

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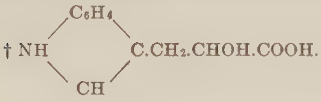
* Prepared from corresponding *l*-glycerates, possibly partly racemized.

†  Compare tryptophane. ‡ Mutarotation.

Mandelic acid and derivatives.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_8H_8O_3$	*l*-Mandelic acid	H_2O	1.56		−157.4	(1698)
$C_8H_9NO_2$	*l*-Mandelamide	Me_2CO	1.65		−73.1	(2214)
	d-Mandelamide	Me_2CO	1.65	9	74.7	
$C_8H_{14}O_3$	*d*-Hexahydromandelic acid	AcOH	*10*	23	−26.6*	(667)
		AcOH	*10*	27	−25.8*	
$C_8H_{15}NO_2$	*d*-Hexahydromandelic amide	20% EtOH	*1.26*	25	47.4*	(667)
$C_9H_{10}O_3$	Methyl *l*-mandelate	CS_2	3.33	22	−214.1	(2090)
		CS_2	1.67	22	−217.0	
		Me_2CO	3.33	22	−110.2	
$C_9H_{10}O_3$	*l*-Methoxyphenylacetic acid	EtOH	6.7656	13.5	−150.0	(1355)
$C_9H_{10}O_4$	*d*-*p*-Methoxymandelic acid	H_2O	*2.5*	19	146.14	(1103)
$C_9H_{11}NO_2$	*l*-α-Methoxyphenylacetamide	Me_2CO	3.457	18	−103.6	(1355)
$C_9H_{16}O_3$	Methyl *d*-hexahydromandelate		1.066	25	−4.7*	
$C_{10}H_{10}O_4$	*l*-Acetylmandelic acid	EtOH	2.22		−157.7	(1341)
		Me_2CO	2.08		−153.7	
$C_{10}H_{12}O_3$	Ethyl *l*-mandelate	$CHCl_3$	6.67	22	−128.4	(2090)
		Me_2CO	5.81	22	−90.62	
		CS_2	5.00	22	−180.0	
$C_{10}H_{13}NO_2$	*l*-Mandeloethylamide	EtOH	3.693	16	−34.4	(1344)
$C_{11}H_{12}O_4$	Methyl *l*-acetylmandelate		1.1546		−146.37	(2090); *cf.* (2100)
$C_{12}H_{14}O_4$	Methyl *l*-propionylmandelate		1.1261		−135.5	(2090)
$C_{12}H_{16}O_3$	Isobutyl *l*-mandelate	CS_2	5		−146.6	(2090); *cf.* (2100)
$C_{13}H_{16}O_4$	Ethyl *l*-propionylmandelate		1.0936		−113.7	(2090)
		$CHCl_3$	10.0		−110.8	
$C_{13}H_{18}O_3$	*dl*-Amyl *l*-mandelate		1.0531		−96.46	(2090)
	l-Amyl *l*-mandelate		1.0530		−94.02	
$C_{15}H_{20}O_4$	Ethyl *l*-valerylmandelate		1.0544		−97.06	(2090)
$C_{17}H_{19}NO_3$	*l*-Hydrindamine *d*-mandelate	EtOH	3.73		−55	(1073)
	d-Hydrindamine *l*-mandelate	EtOH	3.37		57	
	d-Hydrindamine *d*-mandelate	EtOH	3.97		53.7	
$C_{20}H_{28}O_4$	*l*-Menthyl *l*-acetylmandelate	EtOH	2.58		−123.1	(1341); *cf.* (2090)
	l-Menthyl *d*-acetylmandelate	EtOH	2.68		8.8	
	l-Menthyl *dl*-acetylmandelate	EtOH	2.53		−57.2	
	Homologues of mandelic acid					
$C_9H_{10}O_3$	*d*-α-Hydroxy-β-phenylpropionic acid	H_2O	2.56	13.5	22.8	(1356)
		EtOH	3.53	12	18.5	
	d-β-Hydroxy-β-phenylpropionic acid	EtOH	5.194	10.5	19.2	(1342)
	l-β-Hydroxy-β-phenylpropionic acid	EtOH	5.15	20	−18.9	(1342)
$C_9H_{10}O_4$	*d*-α-Hydroxy-β-*p*-hydroxyphenylpropionic acid	H_2O	*1.13*	20	18.14	(411)
$C_9H_{11}NO_2$	*d*-α-Hydroxy-β-phenylpropionamide	EtOH	2.076	20	81.4	(1344)
	d-β-Hydroxy-β-phenylpropionamide	EtOH	4.43	13	38.4	(1344)
$C_{11}H_{14}O_3$	*l*-Isopropylphenylglycolic acid	EtOH	4.09	17	−135	(452, 453)
$C_{11}H_{14}O_3$	Ethyl *l*-β-hydroxy-β-phenylpropionate	EtOH	4.72	20	−14.1	(1342)
		H_2O	2.16	20	22.22	(411)
$C_{11}H_{15}NO_2$	*l*-β-Hydroxy-β-phenylpropionethylamide	EtOH	3.99	15.5	−26.2	(1344)
	Other hydroxymonocarboxylic acids and derivatives					
$C_6H_{12}O_3$	*l*-Leucic acid ($(CH_3)_2CHCH_2CH(OH).COOH$)	H_2O	*9.854*	20	−10.4	(1867)
	Sodium salt	H_2O	*9.828*†	20	−27.8	(1867)
$C_8H_{16}O_3$	Ethyl *l*-leucate		0.965	20	−11.07	(1867)
$C_{15}H_{30}O_3$	Convolvulinolic acid ($C_{14}H_{28}(OH).COOH$)	$CHCl_3$	20.869		1.39	(1705); *cf.* (1702)
$C_{16}H_{32}O_3$	Methyl convolvulinolate	$CHCl_3$	10.07		1.57	(1705)
$C_{16}H_{32}O_3$	Hydroxyhexadecylic or jalapinolic acid ($C_{15}H_{30}(OH).COOH$)	$CHCl_3$	17.76		0.79	(1705)
$C_{17}H_{34}O_3$	Methyl hydroxyhexadecylate	$CHCl_3$	14.38		0.98	(1705, 1760)
		$CHCl_3$	18.63		0.94	
$C_{18}H_{32}O_3$	Ricinostearolic acid ($C_{17}H_{30}(OH).COOH$)	Me_2CO	6.4		13.67	(2088)
$C_{18}H_{34}O_3$	Ricinoleic acid ($CH_3.(CH_2)_5.CHOH.CH{:}CH(CH_2)_8.COOH$)	Me_2CO	4.8–21	22	6.25–7.5	(2088)

* λ = 5461. † Mutarotation.

Other hydroxymonocarboxylic acids and derivatives.—(Continued)

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_{18}H_{34}O_3$	Ricinelaidic acid	Me_2CO	5		4.8	(2088)
		EtOH	12		6.67	
$C_{19}H_{36}O_3$	Methyl ricinoleate		0.927	15	5.20	(798)
$C_{20}H_{38}O_3$	Ethyl ricinoleate		0.918	15	4.48	(798)
$C_{21}H_{40}O_3$	*n*-Propyl ricinoleate		0.912	15	4.35	(798)
$C_{22}H_{42}O_3$	Isobutyl ricinoleate		0.908	15	4.22	(798)
$C_{25}H_{50}O_3$	Cerebronic acid ($C_{23}H_{47}$.CHOH.COOH)	EtOH	*6.0*	20	3.55	(1239)

DIHYDROXYMONOCARBOXYLIC ACIDS

Glyceric acid and derivatives (including thio-compounds)

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_3H_6O_4$	*d*-Glyceric acid: Barium salt	H_2O	*9.89*	20	−10.93	(638)
		H_2O	7.70		−17.38	(1509); *cf.* (632, 640, 649, 1243, 1510)
$C_3H_6O_4$	*l*-Glyceric acid	H_2O	*9.53*	20	12.94	(517)
$C_3H_7NO_3$	Glycerylamide		1.3347	100	−39.98	(664)
			1.3048	136	−38.11	
		MeOH	*2.439*	20	−63.09	
$C_4H_8O_4$	Methyl *d*-glycerate		1.2798	15	−4.80	(649); *cf.*
$C_5H_{10}O_4$	Ethyl *d*-glycerate		1.1921	15	−9.18	(633, 655)
$C_5H_{11}NO_3$	α, β-Dimethoxypropionamide	MeOH	*3.13*	20	−54.55	(642)
		Py	*1.696*	20	−71.60	
$C_6H_{10}O_6S_2$	β-Dithio-α-hydroxypropionic acid ([S.CH_2.CH(OH).COOH]$_2$)	H_2O	3.21		−10.6	(1501)
	Barium salt	H_2O	5.08	22	−19.08	(1501)
$C_6H_{12}O_4$	*n*-Propyl *d*-glycerate		1.1448	17	−12.94	(649); *cf.* (633, 655)
$C_6H_{12}O_4$	Isopropyl *d*-glycerate		1.1303	15	−11.82	(649)
$C_6H_{12}O_4$	Methyl α, β-dimethoxypropionate		1.0634	20	−69.70	(642)
$C_6H_{13}NO_3$	α, β-Dimethoxypropionic methylamide	MeOH	*1.892*	20	−58.72	(642)
$C_7H_{14}O_4$	*n*-Butyl *d*-glycerate		1.1084	17	−13.19	(649); *cf.* (633, 655)
	Isobutyl *d*-glycerate		1.1051	18	−14.23	
	sec.-Butyl *d*-glycerate		1.1052	19	−10.58	
$C_7H_{14}O_4$	Ethyl α, β-dimethoxypropionate		1.0309	20	−69.95	(642)
$C_8H_{16}O_4$	Propyl α, β-dimethoxypropionate		1.0090	20	−69.01	(642)
$C_9H_{18}O_4$	Butyl α, β-dimethoxypropionate		0.9921	20	−64.88	(642)
$C_9H_{11}NO_3$	Glycerylanilide		1.2084	100	−39.98	(664)
			1.1752	139	−36.16	
		MeOH	*2.44*	20	−72.13	
		MeOH	*5.66*	20	−67.29	
$C_{10}H_{13}NO_3$	Glyceryl-*o*-toluidide	MeOH	*2.44*	20	−32.55	(664)
		MeOH	*5.66*	20	−37.18	
	Glyceryl-*p*-toluidide	MeOH	*2.44*	20	−63.97	
			1.2121	98	−34.69	
			1.1376	179	−29.62	
$C_{10}H_{20}O_4$	Heptyl *d*-glycerate		1.0390	18	−11.30	(649); *cf.* (633, 655)
$C_{11}H_{22}O_4$	Octyl *d*-glycerate		1.0263	19	−10.22	
$C_{12}H_{24}O_4$	Heptyl α, β-dimethoxypropionate		0.9571	20	−54.84	(642)
$C_{13}H_{26}O_4$	Octyl α, β-dimethoxypropionate		0.9527	20	−50.46	(642)

SIMPLE DICARBOXYLIC ACIDS

Phenylsuccinic acid and derivatives (2217)

Formula	Name	Solvent	C	t, °C	$[\alpha]_D$
$C_{10}H_{10}O_4$	α-Phenylsuccinic acid	Me_2CO	1.802	15.4	173.4
		EtOH	1.534	16.5	148.3
		AcOEt	1.550	15.5	174.2
	l-Phenylsuccinic acid	Me_2CO	1.483	14.5	−173.3
		MeOH	1.941	12.5	−147.1
$C_{12}H_{14}O_4$	Dimethyl *d*-phenylsuccinate	Me_2CO	1.723	10	142.2
		C_6H_6	1.443	15	159.0
		CCl_4	1.272	15	169.8
		EtOH	1.558	12	140.9
		AcOEt	1.267	11.5	150.7

Phenylsuccinic acid and derivatives (2217).—(*Continued*)

Formula	Name	Solvent	*C*	*t*, °C	$[\alpha]_D$
$C_{14}H_{18}O_4$	Diethyl *d*-phenylsuccinate	Me_2CO	3.090	13	103.4
		CCl_4	1.853	16	130.6
		EtOH	2.242	15.5	100.8
$C_{10}H_8O_3$	*d*-Phenylsuccinic anhydride	C_6H_6	1.298	15	100.9
		PhMe	1.500	12.5	102.7
		AcOEt	1.090	16	90.8
	l-Phenylsuccinic anhydride	C_6H_6	1.382	14	−100.9
		$CHCl_3$	0.954	10.5	−92.2

d-β-Octyl alkyl esters of dicarboxylic acids (778)

Formula	Name	$[\alpha]_D^{20}$
$C_{11}H_{20}O_4$	Octyl methyl oxalate	14.22
$C_{12}H_{22}O_4$	Octyl ethyl oxalate	13.98
$C_{13}H_{24}O_4$	Octyl ethyl malonate	9.27
$C_{13}H_{24}O_4$	*l*-β-Octyl methyl succinate	− 3.54
$C_{18}H_{34}O_4$	Dioctyl oxalate	22.72
$C_{22}H_{42}O_4$	Dioctyl adipate	11.23
$C_{24}H_{46}O_4$	Dioctyl suberate	11.01
$C_{27}H_{52}O_4$	Octyl *n*-nonane-*i*-dicarboxylate	10.37
$C_{28}H_{54}O_4$	Octyl *n*-decane-*k*-dicarboxylate	10.36
$C_{29}H_{56}O_4$	Octyl *n*-undecanedicarboxylate	9.25

Alkylisopropyl carbinyl hydrogen phthalates in 5% $CHCl_3$ solution (1620)

Formula	Alkyl	$[\alpha]_D^{20}$ (?)
$C_{13}H_{16}O_4$	*d*-Methyl	37.9
$C_{14}H_{18}O_4$	*d*-Ethyl	− 0.5
$C_{15}H_{20}O_4$	*d*-Propyl	7.8
$C_{16}H_{22}O_4$	*d*-*n*-Butyl	13.9
$C_{17}H_{24}O_4$	*d*-*n*-Amyl	13.5
$C_{18}H_{26}O_4$	*d*-*n*-Hexyl	11.8
$C_{20}H_{30}O_4$	*d*-*n*-Octyl	16.9
$C_{22}H_{34}O_4$	*d*-*n*-Decyl	13.9

MONOHALOGENODICARBOXYLIC ACIDS

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_4H_3ClO_3$	*d*-Chlorosuccinic anhydride	AcOEt	10		30.85	(2089)
$C_4H_3Cl_3O_2$	*d*-Chlorosuccinyl chloride	AcOEt	5		33.60	(2089)
			1.5002	20	29.53	(2086)
$C_4H_5BrO_4$	*d*-Bromosuccinic acid	Et_2O	4.65	20	60.5	(1238)
		H_2O	11.64	20	35.2	
	l-Bromosuccinic acid	Et_2O	5.33		−67.92	(2089, 2091)
		AcOEt	6.66		−72.7	
$C_4H_5ClO_4$	*d*-Chlorosuccinic acid	H_2O	2.706	18.5	20.1	(1330)
		H_2O	16	21	20.6	(2086)
		H_2O	3.2	21	21.3	
		AcOEt	10		52.85	(2089)
$C_4H_5IO_4$	*l*-Iodosuccinic acid	AcOEt	5.58	19	−89.8	(920.5)
		EtOH	2.95	19	−76.2	
		H_2O	2.67	19	−54.9	
	Sodium hydrogen salt	0.5*N* H_2SO_4	6.7	19	−55.1	(920.5)
		H_2O	6.12	19	−35.6	
		H_2O	5	19	−46.5	
$C_4H_6BrNO_3$	*l*-Bromosuccinamic acid	EtOH	6.66		−67.12	(2089, 2091)
		AcOEt	6.66		−67.57	
		20% H_2SO_4	3.00		−44.3	
$C_5H_7ClO_4$	*l*-α-Chloroglutaric acid	H_2O	*36.2*	18	−12.6	(526)
$C_6H_9BrO_4$	Dimethyl *d*-bromosuccinate				50.83	(2091)
$C_8H_{13}BrO_4$	Diethyl *d*-bromosuccinate				40.96	(2091)
$C_8H_{13}ClO_4$	Diethyl *d*-chlorosuccinate			20	31.33	(372)
			$1.152_4^{19.5}$	19.8	32.7	(1330)
$C_{10}H_{17}BrO_4$	Dipropyl *d*-bromosuccinate		1.3010		38.05	(2089)
$C_{15}H_{25}BrO_4$	α-Methyl β-menthyl bromosuccinate		1.181	20	−46.1	(344)
	β-Methyl α-menthyl bromosuccinate		1.210	20	−49.1	(344)

MONOHYDROXYDICARBOXYLIC ACIDS

Malic acid and derivatives

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_4H_6O_5$	*d*-Malic acid*	H_2O	7	19	2.33	(364)
	d-Malic acid, uranyl salt	1% UO_4Ac_2	5	18	483	(364); *cf.* (371)
$C_4H_6O_5$	*l*-Malic acid*	H_2O	*20*	9	−0.65	(331); *cf.* (2197)
		H_2O	*20*	45.5	−2.45	

* Anhydrous acid: (2093, 2097, 2098). In water solution (20.5, 239, 666, 756, 1162.5, 1486, 1561, 1878, 2018, 2212.5). In acetone solution (20.5, 767.5, 1486, 2092, 2093, 2098). In propyl alcohol (1486). In methyl alcohol (1486, 2093). In acetaldehyde (2098). In benzaldehyde (2098). In pyridine (756, 920, 2098). In isobutyl alcohol (2098). Influence of concentration (1486, 2212.5). Influence of temperature (756, 1486, 2212.5). Influence of boric acid (756, 1486). Influence of various solvents (756, 1486, 2098). Influence of inactive substances (331, 1362, 1878, 1989, 2096.5). Dispersion (1486, 2098). Influence of uranyl nitrate (66.5, 2095). Influence of molybdic acid and molybdates (369, 755, 990). Normal and acid salts of *l*-malic acid and K, Na, Li, NH_4, Ba (1878, 2018, 2021).

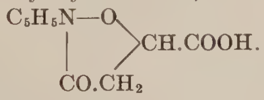
Ammonium antimonyl malate (1561): Influence of *d*-malic acid (239, 240, 1648, 2093.5, 2100.5).

Malic acid and derivatives.—(Continued)

Formula	Name	Solvent	d, C or %	t, °C	[α]$_D$	Lit.
$C_6H_8O_6$	*l*-Acetylmalic acid	H_2O	10.9		−10.7	(916)
	Sodium hydrogen salt	H_2O	5.18*		−1.46*	(916)
	Esters of malic acid					
$C_5H_6O_5$	Methylene malate	MeOH	1		−3	(1262.5)
$C_6H_{10}O_5$	Dimethyl *l*-malate; *cf.* (38, 752.5, 1745)		1.2337		−6.85	(2089)
			1.238	15	−6.80	(331, 370); *cf.* (1590, 2089)
			1.149	100	−7.31	
		H_2O	*9.73*	12	−11.07	
		H_2O	*9.73*	50	−9.64	
$C_8H_{14}O_5$	Diethyl *l*-malate; *cf.* (38, 1590, 1745)		1.1294	20	−10.18	(2089)
$C_{10}H_{18}O_5$	Dipropyl *l*-malate		1.0745	20	−11.62	(2089); *cf.* (38, 1745, 2100)
	Diisopropyl malate		1.0760	20	−10.41	
$C_{12}H_{22}O_5$	Di-*n*-butyl *l*-malate		1.0382	20	−10.72	(38, 1745)
	Diisobutyl malate		1.0418	20	−11.14	(2089); *cf.* (2100)
				20	−10.26	(1587)
	In methyl thiocyanate		*9.45*		−11.8	
	In ethyl thiocyanate		*10.21*		−12.6	
	In ethyl isothiocyanate		*10.09*		−12.3	
	In isobutyl thiocyanate		*10.64*		−10.3	
	In isobutyl isothiocyanate		*10.66*		−10.4	
	In ethyl ethylacetoacetate		*10.21*		−10.8	
	In nitrobenzene		*8.52*		−11.0	
	In tetrabromoethane		*3.60*		2.3	
$C_{14}H_{26}O_5$	Di-*dl*-amyl malate		1.079	20	−9.92	(2089)
$C_{14}H_{26}O_5$	Di-*l*-amyl malate		1.0176	20	−6.88	(2089)
$C_{20}H_{38}O_5$	Dioctyl malate†		0.9761	20	−6.92	(2089)
	Esters of nitromalic acid					
$C_6H_9NO_7$	Dimethyl nitromalate		1.318	20	−33.01	(2099)
		$CHCl_3$	4.0	20	−18.80	(2089)
$C_8H_{13}NO_7$	Diethyl nitromalate		1.2090	20	−31.24	(2099)
$C_{10}H_{17}NO_7$	Di-*n*-propyl nitromalate		1.1932	20	−25.65	(2099)
	Esters of acylmalic acids					
$C_8H_{11}BrO_6$	Dimethyl bromoacetyl-*l*-malate		1.5072	20	−22.40	(2089)
$C_8H_{11}ClO_6$	Dimethyl chloroacetyl-*l*-malate		1.3062	20	−23.30	(2089)
$C_8H_{12}O_6$	Dimethyl acetyl-*l*-malate		1.1975	20	−22.92	(2089); *cf.* (2100)
$C_{10}H_{16}O_6$	Diethyl acetyl-*l*-malate; *cf.* (38, 1590, 1745, 2089, 2100)		1.1169	20	−22.6	(1773)
$C_9H_{14}O_6$	Dimethyl propionyl-*l*-malate		1.1609	20	−22.94	(2089); *cf.* (2100)
$C_{10}H_{15}BrO_6$	Diethyl bromoacetyl-*l*-malate		1.3936	20	−22.48	(2089)
$C_{10}H_{15}ClO_6$	Diethyl chloroacetylmalate		1.2062	20	3.07	(2100); *cf.* (38, 1745)
$C_{10}H_{16}O_6$	Dimethyl *n*-butyryl-*l*-malate		1.1317	20	−22.44	(2089)
	Dimethyl isobutyryl-*l*-malate		1.1255	20	−22.36	
$C_{11}H_{17}BrO_6$	Diethyl α-bromopropionyl-*l*-malate		1.3325	20	−22.48	(2089)
$C_{11}H_{18}O_6$	Dimethyl isovaleryl-*l*-malate		1.1034	20	−22.39	(2089)
	Diethyl propionyl-*l*-malate		1.0926	20	−22.79	(1773); *cf.* (2089, 2100)
$C_{12}H_{19}ClO_6$	Dipropyl chloroacetyl-*l*-malate		1.1566	20	−23.52	(2089)
$C_{12}H_{19}BrO_6$	Diethyl α-bromobutyryl-*l*-malate		1.3059	20	−24.76	(2089)
	Diethyl α-bromoisobutyryl-*l*-malate		1.2850	20	−22.57	(2089)
	Dipropyl bromoacetyl-*l*-malate		1.3150	20	−22.24	(2089)
$C_{12}H_{20}O_6$	Diethyl *n*-butyryl-*l*-malate; *cf.* (2089, 2100)		1.0735	20	−22.75	(1773)
	Diethyl isobutyryl-*l*-malate; *cf.* (2100)		1.0688	20	−21.99	(2089)
$C_{12}H_{20}O_6$	Dipropyl acetyl-*l*-malate; *cf.* (38, 1745, 2100)		1.0724	20	−22.85	(2089)
$C_{13}H_{22}O_6$	Diethyl *n*-valeryl-*l*-malate		1.0551	20	−21.38	(1773)
	Diethyl isovaleryl-*l*-malate		1.0605	20	−22.07	(2089)

* Calculated on weight of acid. † Described by author as dicapryl malate.

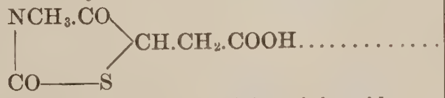
Esters of acylmalic acids.—(Continued)

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_{14}H_{23}BrO_6$	Diisobutyl bromoacetyl-*l*-malate		1.2022	20	−20.38	(2089)
$C_{14}H_{24}O_6$	Diethyl *n*-hexoyl-*l*-malate		1.0420	20	−20.30	(1773)
	Dipropyl *n*-butyryl-*l*-malate		1.0417	20	−22.40	(2089); *cf.* (2100)
	Di-*n*-butyl acetyl-*l*-malate		1.0430	20	−19.93	(38); *cf.* (1745)
	Diisobutyl acetyl-*l*-malate		1.0362	20	−21.88	(2089); *cf.* (2100)
$C_{15}H_{26}O_6$	Diethyl *n*-heptoyl-*l*-malate		1.0289	20	−19.30	(1773)
	Dipropyl isovaleryl-*l*-malate		1.0263	20	−21.68	(2089)
$C_{16}H_{28}O_6$	Diethyl *n*-octoyl-*l*-malate		1.0162	20	−18.21	(1773)
$C_{16}H_{28}O_6$	Diisobutyl *n*-butyryl-*l*-malate		1.0146	20	−21.68	(2089)
$C_{17}H_{30}O_6$	Diethyl pelargonyl-*l*-malate		1.0073	20	−17.24	(1773)
	Diisobutyl isovaleryl-*l*-malate		1.0045	20	−19.91	(2089)
$C_{18}H_{32}O_6$	Diethyl decoyl-*l*-malate		1.0011	20	−16.61	(1773)
	Monoamides of malic acid					
$C_4H_7NO_4$	*d*-β-Malamic acid [$NH_2.CO.CH_2.CHOH.(COOH)$]	H_2O	3		9.70	(1313.5, 1314)
	Silver salt	H_2O	5		16.4	
$C_5H_9NO_4$	*d*-β-*N*-Methylmalamic acid	H_2O	3.30	20	13.0	(1318)
	Methyl *d*-β-malamate	MeOH	5		12.7	(1313.5)
	Methyl *l*-β-malamate	MeOH	5		−48.48	
$C_7H_{12}N_2O_3$	*d*-β-Malamic allylamide ($C_3H_5.NH.CO.CHOH.CH_2.CO.NH_2$)	MeOH	2.5		49.68	(1313.5)
	l-α-Malamic allylamide	MeOH	1.90		−52.25	
$C_9H_9NO_4$	*d*-Pyridylmalic acid,  $C_5H_5N—O—CH(COOH)—CH_2.CO—$	0.4*N* HCl	5		10.6	(1313.5)
	Sodium salt	H_2O	3.01		17.01	(1313.5)
$C_{11}H_{13}NO_4$	*d*-β-*N*-Benzylmalamic acid	MeOH	5		13.6	(1313.5)
	[$C_7H_7.NH.CO.CH_2.CHOH.COOH)$]	MeOH	2.5		14.32	
	Sodium salt	H_2O	2.95		33.8	
$C_{12}H_{15}NO_4$	Methyl *d*-β-*N*-benzylmalamate	MeOH	2.5		12.8	(1313.5)
	Methyl *l*-β-*N*-benzylmalamate	MeOH	2.5	20	−12.8	(1315)
$C_{18}H_{19}NO_4$	*l*-*N*-Dibenzylmalamic acid [$(C_7H_7)_2N.CO.CH_2.CHOH.COOH$]	EtOH	1.25	18.5	−61.6	(1317)
$C_{18}H_{22}N_2O_4$	Benzylamine *d*-β-*N*-benzylmalamate	MeOH	5	20	31.43	(1313.5)
		H_2O	2.5		28.0	(1315)
	Diamides of malic acid					
$C_4H_8N_2O_3$	*l*-Malic diamide	H_2O	4.32	20	−37.6	(2089)
		H_2O	8.65	20	−38.0	
		AcOH	4.678	20	−45.2	(1321)
		Py	2.00	20	−57.7	
$C_6H_{12}N_2O_3$	*l*-Malic dimethylamide	Py	*10.08*	20	−56.27	(639)
		MeOH	*9.982*	20	−67.42	
		AcOH	*8.185*	20	−73.26	
$C_8H_{16}N_2O_3$	*l*-Malic diethylamide	Py	*10.25*	20	−47.41	(639)
		MeOH	*9.18*	20	−59.47	
		AcOH	*7.995*	20	−62.34	
$C_{10}H_{16}N_2O_3$	*l*-Malic diallylamide	Py	*10.4*	20	−34.89	(639)
		MeOH	*9.1*	20	−48.72	
		AcOH	*10.8*	20	−41.22	
$C_{10}H_{20}N_2O_3$	*l*-Malic diisopropylamide	Py	*3.99*	20	−31.93	(639)
		MeOH	*6.04*	20	−41.79	
		AcOH	*6.28*	20	−42.83	
$C_{10}H_{20}N_2O_3$	*l*-Malic di-*n*-propylamide	Py	*7.9*	20	−41.11	(639)
		Py	4.79	17	−41.9	
		MeOH	*11.34*	20	−53.10	
		AcOH	*9.05*	20	−52.20	
		AcOH	4.80	16	−47.4	
$C_{11}H_{14}N_2O_3$	*d*-β-*N*-Benzylmalamide	MeOH	2.5		42.40	(1313.5)

Diamides of malic acid.—(Continued)

Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{12}H_{24}N_2O_3$	*l*-Malic di-*n*-butylamide	Py	*10.85*	20	−35.35	(639)
		MeOH	*10.54*	20	−45.9	
		AcOH	*9.72*	20	−43.01	
$C_{12}H_{24}N_2O_3$	*l*-Malic diisobutylamide	Py	*7.98*	20	−36.64	
		MeOH	*9.12*	20	−48.53	
		AcOH	*7.56*	20	−43.25	
$C_{14}H_{24}N_2O_3$	*l*-Malic dipiperidide	Py	*0.598*	20	−20.58	(639)
		MeOH	*8.85*	20	−27.47	
		AcOH	*6.53*	20	−15.08	
$C_{16}H_{16}N_2O_3$	*l*-Malic dianilide	AcOH	1.50	20	−60.66	(2089)
		AcOH	0.75	20	−58.66	
$C_{18}H_{20}N_2O_3$	*l*-Malic di-*o*-toluidide	AcOH	2.00	20	−65.0	(2089)
		AcOH	1.00	20	−66.5	
	l-Malic di-*p*-toluidide	AcOH	1.00	20	−70.0	
$C_{18}H_{20}N_2O_3$	*l*-Malic dibenzylamide	AcOH	4.65	22	−20.2	(2089)
		Py	4.86	15	−32.4	
$C_{18}H_{36}N_2O_3$	*l*-Malic di-*n*-heptylamide	Py	*11.01*	20	−27.08	(639)
		MeOH	*6.00*	20	−35.38	
		AcOH	*9.33*	20	−31.20	
	Imides of malic acid					
$C_{11}H_{11}NO_3$	*d*-Benzylmalimide	EtOH	2	18	58.67	(1316)
$C_{18}H_{15}NO_4$	*d*-*O*-Benzoyl-*N*-benzylmalimide	Me_2CO	2		24.7	(1316)
	Methoxysuccinic acid and derivatives					
$C_5H_6Cl_2O_3$	*l*-Methoxysuccinyl chloride	C_6H_6	6.4317	20	−54.18	(1747)
$C_5H_6O_4$	*l*-Methoxysuccinic anhydride	Me_2CO	5.6783	20	−83.91	(1747)
		C_6H_6	4.9973	20	−103.3	
$C_5H_8O_5$	*d*-Methoxysuccinic acid	H_2O	11.2	18	33.30	(1738)
		Me_2CO	24.96	11	57.10	(1730)
		Me_2CO	1.65	14	60.09	
		AcOEt	20.5	11	63.48	
		AcOEt	8.92	12	64.64	
	Ammonium hydrogen salt	H_2O	6.06	14	25.86	(1738)
	Ammonium salt	H_2O	5.762	14	12.32	(1738)
	Barium salt	H_2O	26.125	18	−14.27	(1738)
		H_2O	12.416	18	−7.36	
		H_2O	5.746	18	−2.21	
		H_2O	1.149	18	3.16	
	Calcium salt	H_2O	5.308	18	−10.10	(1738)
	Potassium hydrogen salt	H_2O	8.15	18.5	23.46	(1738)
	Potassium salt	H_2O	12.16	15.5	9.54	(1738)
$C_5H_8O_5$	*l*-Methoxysuccinic acid	H_2O	6.135	15	−33.56	(1747)
$C_5H_9NO_4$	*l*-Methoxysuccinamic acid	H_2O	4.7777	20	−29.41	(1747)
		MeOH	3.251	20	−46.75	
$C_5H_{10}N_2O_3$	*l*-Methoxysuccindiamide	H_2O	7.4860	20	−40.7	(1739)
		MeOH	1.0460	20	−56.9	
		AcOH	3.9954	20	−41.7	
		Py	0.2740	20	−80.3	
$C_6H_{10}O_5$	Methyl hydrogen *l*-methoxysuccinate	H_2O	6.3086	20	−41.85	(1747)
		H_2O	3.1543	20	−43.28	
		Me_2CO	6.9747	20	−60.86	
		Me_2CO	3.4874	20	−57.64	
		H_2O	3.936	16	−19.05	
$C_7H_{12}O_5$	Dimethyl *l*-methoxysuccinate		1.1415		−62.79	(1739); *cf.* (1744)
		MeOH	20.01	20	−51.5	
		MeOH	10.05	20	−51.3	
		MeOH	5.00	20	−51.7	
		C_6H_6	19.97	20	−65.1	
		C_6H_6	10.02	20	−67.2	
		C_6H_6	5.04	20	−68.3	
$C_9H_{16}O_5$	Diethyl *l*-methoxysuccinate		1.0705_4^{18}	18	−50.11	(1744)
			1.0676	20	−50.4	(1739)
			1.0476	40	−49.7	
			1.0273	60	−49.2	

Methoxysuccinic acid and derivatives.—(Continued)

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_9H_{16}O_5$	Diethyl *l*-methoxysuccinate.—(*Continued*)	C_6H_6	20.043	20	−58.0	
		C_6H_6	10.01	20	−59.1	
		C_6H_6	5.034	20	−60.6	
		EtOH	19.92	20	−47.1	
		EtOH	9.97	20	−47.7	
		EtOH	5.03	20	−47.8	
$C_{11}H_{20}O_5$	Dipropyl *l*-methoxysuccinate		1.0419^{15}_{4}	15	−45.21	(1744)
			1.0312	20	−46.9	(1739)
			1.0101	40	−46.3	
			0.9908	60	−45.5	
		C_6H_6	19.91	20	−52.7	
		C_6H_6	10.01	20	−54.2	
		C_6H_6	4.99	20	−54.6	
		EtOH	19.83	20	−43.6	
		EtOH	6.00	20	−43.2	
$C_{13}H_{24}O_5$	Di-*n*-butyl *l*-methoxysuccinate		1.0419^{15}_{4}	15	−41.63	(1744)
$C_{17}H_{18}N_2O_3$	*l*-Methoxysuccindianilide	MeOH	2.1096	16	−77.5	(1739)
		AcOH	2.1193	20	−53.3	
		Py	2.4546	20	−66.3	
$C_{43}H_{52}N_4O_7$	Dicinchonine *d*-methoxysuccinate	H_2O	4	17	154.89	(1738)
	Other alkyloxysuccinic acids and derivatives					
$C_6H_{10}O_5$	*d*-Ethoxysuccinic acid	H_2O	11.17	17	33.02	(1743, 1744)
		$CHCl_3$	11.61	12	47.75	
		$CHCl_3$	1.60	11	39.40	
		EtOH	11.81	11	60.57	
		AcOEt	11.5	18	69.9	
		Me_2CO	9.57	14	−63.39	
		Me_2CO	1.53	14	−66.48	
	Ammonium hydrogen salt $+H_2O$	H_2O	8.13	15	28.65	
	Ammonium salt	H_2O	5.22	12	18.29	
	Barium salt	H_2O	4.56	18	6.37	
		H_2O	10.77	18	2.46	
		H_2O	25.08	19	−4.37	
	Calcium salt	H_2O	3.04	15	8.39	
		H_2O	1.79	15	11.44	
	Potassium hydrogen salt	H_2O	3.93	19	26.49	
$C_7H_{12}O_5$	*l*-Propoxysuccinic acid	H_2O	7.76	12	−36.40	(1730)
		Me_2CO	5.688	12	−63.29	
	Barium salt	H_2O	3.65	18	−10.00	(1730)
$C_8H_{14}O_5$	Dimethyl *d*-ethoxysuccinate		1.1055		59.86	(1740)
$C_{10}H_{18}O_5$	Diethyl *d*-ethoxysuccinate		1.0418		55.29	(1740)
$C_{12}H_{22}O_5$	Dipropyl *l*-ethoxysuccinate		1.0226		−51.20	(1740)
$C_{14}H_{26}O_5$	Di-*n*-butyl *l*-ethoxysuccinate		1.0045		−46.43	(1740)
	Sulfur derivatives of malic acid					
$C_4H_6O_4S$	*l*-Thiomalic acid (HOOC.CH(SH).CH$_2$.COOH)	AcOEt	5	17	−76.5	(920.2)
		Me_2CO	5	17	−75.8	
		EtOH	5	17	−64.8	
		H_2O	5	17	−46.7	
$C_4H_7NO_3S$	*d*-β-Thiolsuccinamic acid (NH$_2$.CO.CH(SH)CH$_2$.COOH)	Me_2CO	2.78	18	82.9	(918)
		H_2O	2.75	18	58.7	
	Sodium salt	H_2O	2.75	19	36.8*	(918)
$C_6H_7NO_4S$	*d*-*N*-Methyldiketothiazolidineacetic acid,  NCH$_3$.CO / CO——S >CH.CH$_2$.COOH	EtOH	2.58		208.0	(1035)
$C_6H_9NO_5S$	*d*-*N*-Methylcarbamidothiolsuccinic acid (CH$_3$.NH.CO.S.CH(COOH).CH$_2$.COOH)	EtOH	1.7		99.2	(1035)
$C_7H_{11}NO_4S_2$	*d*-β-Ethylxanthosuccinamic acid (NH$_2$.CO.CH(S.CS.OC$_2$H$_5$).CH$_2$.COOH)	Me_2CO	6.59	18	55.5	(918)
		AcOEt	2.63	17	66	

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* Calculated on weight of acid.

Sulfur derivatives of malic acid.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_7H_{11}NO_5S$	*d*-*N*-Dimethylcarbamidothiolsuccinic acid	EtOH	2.01		81.7	(1035)
	d-*N*-Ethylcarbamidothiolsuccinic acid	EtOH	1.45		103.5	(1035)
	Other monohydroxydicarboxylic acids					
$C_5H_8O_5$	*d*-α-Hydroxyglutaric acid	H_2O	*32.7*	25	8.8	(526)
	MONOAMINOMONOCARBOXYLIC ACIDS					
	Derivatives of glycine (aminoacetic acid, $NH_2.CH_2.COOH$)					
$C_5H_8BrNO_3$	*l*-α-Bromopropionylglycine	H_2O	*8.10*	20	−35.27	(474)
	($CH_3.CHBr.CO.NH.CH_2.COOH$)	EtOH	*10.2*	20	−46.6	
$C_5H_8BrNO_3$	*d*-α-Bromopropionylglycine	H_2O	*10.1*	18	38.3	(479)
$C_8H_{14}BrNO_3$	*d*-α-Bromoisohexoylglycine	EtOH	*9.23*	20	62.0	(473)
$C_8H_{14}BrNO_3$	*d*-α-Bromo-β-methylvalerylglycine	EtOH	*4.44*	20	64.42	(13)
$C_{11}H_{12}BrNO_3$	*d*-α-Bromo-β-phenylpropionylglycine	EtOH	*4.31*	20	−14.65	(546)
	Alanine (α-aminopropionic acid, $CH_3.CH(NH_2)COOH$) and derivatives					
$C_3H_8N_2O$	*d*-Alanineamide	H_2O	*5.2*		6	(1120)
$C_4H_8N_2O_3$	*l*-α-Carbamidopropionic acid	H_2O	1.28	20	−9.6	(363)
$C_4H_9NO_2$	*d*-*N*-Methylalanine	H_2O	*9.99*	20	5.59	(523)
		H_2O	*8.29*	20	5.92	(524)
$C_4H_{10}ClNO_2$	*d*-*N*-Methylalanine hydrochloride	H_2O	*9.21*	20	5.74	(523)
$C_5H_8ClNO_3$	Chloroacetyl-*d*-alanine	H_2O	*8.67*	20	−45	(547)
$C_5H_8N_2O_2$	Glycyl-*d*-alanine anhydride	H_2O	*4.69*	20	−5.0	(547)
$C_5H_{10}N_2O_3$	Glycyl-*d*-alanine	H_2O	*8.68*	20	−50	(547)
$C_6H_{10}BrNO_3$	*dl*-α-Bromopropionyl-*d*-alanine	MeOH	*10.7*	20	−26.6	(547)
		H_2O	*2.38*	23	−42.4	
	l-α-Bromopropionyl-*d*-alanine	H_2O	*2.34*	21	−16.5	(547)
		MeOH	*10.48*	21	0.6	
		H_2O	*5*	20	−63.6	(536)
	d-α-Bromopropionyl-*l*-alanine	H_2O	*2.69*	20	67.91	(537)
$C_6H_{10}N_2O_2$	*d*-Alanine anhydride	H_2O	*1.97*	20	28.8	(471)
$C_6H_{13}NO_2$	*l*-Trimethyl-α-propiobetaine*	H_2O	*9.78*	20	−19.7	(477)
$C_9H_{16}BrNO_3$	*d*-α-Bromoisohexoyl-*d*-alanine	EtOH	*9.85*	20	23.0	(473)
$C_{10}H_{10}N_2O$	*l*-Benzoylaminopropionitrile	95% EtOH	4.90	15	−55.84	(375)
$C_{10}H_{13}NO_2$	*N*-Benzylalanine	5*N* HCl	*2.19*	20	−3.4	(524)
$C_{10}H_{13}NO_4S$	*p*-Toluenesulfonyl-*d*-alanine	EtOH		20	−7.26	(523)
	p-Toluenesulfonyl-*l*-alanine	EtOH	2.36	25	7.71	(717)
$C_{11}H_9NO_4$	Phthalyl-*d*-alanine	EtOH	*9.83*	20	−17.84	(474)
$C_{11}H_{15}NO_4S$	*p*-Toluenesulfonyl-*d*-*N*-methylalanine	EtOH	10.37	20	−6.67	(546)
$C_{12}H_{17}NO_4S$	*p*-Toluenesulfonyl-*d*-alanine ethyl ester	EtOH	*3.16*	20	−34.2	(524)
$C_{13}H_{13}NO_4$	Phthalyl-*d*-alanine ethyl ester	EtOH	*10.2*	20	−12.33	(474)
$C_{17}H_{19}NO_4S$	*p*-Toluenesulfonyl-*N*-benzyl-*d*-alanine	EtOH	*4.88*	20	−3.80	(524)
	Serine and isoserine and derivatives					
$C_3H_7NO_3$	*d*-Serine (α-amino-β-hydroxypropionic acid, $HO.CH_2.CH(NH_2).COOH$)	H_2O	*10*	20	−16.87	(516, 517)
$C_3H_7NO_3$	*l*-Isoserine (α-hydroxy-β-aminopropionic acid, $NH_2.CH_2.CHOH.COOH$)	*N* HCl	*8.95*	20	−14.32	(516, 517)
		H_2O	*10*	20	−32.58	(516, 517)
$C_{10}H_{11}NO_4$	Benzoyl-*l*-isoserine	H_2O	*9.98*	20	10.5	(516, 517)
$C_{10}H_{10}N_2O_6$	*p*-Nitrobenzoyl-*d*-serine	0.04*N* NaOH	*10*	20	−43.74	(516, 517)
$C_{11}H_{13}NO_4$	*d*-Benzoyl-α-methylisoserine	EtOH	*10*	20	9.51	(1046)
	Cystine and cysteine and derivatives					
$C_3H_7NO_2S$	Cysteine ($HS.CH_2.CH(NH_2)COOH$)	25% HCl	1.00		−224	(1505)
		25% HCl	0.962		−206	
$C_6H_{12}N_2O_4S_2$	*l*-Cystine [$(S.CH_2.CH(NH_2)COOH)_2$]; *cf.* (97, 1138.4, 1401.5)	*N* HCl	*1.89*	20	−209.6	(538)
$C_8H_{13}ClN_2O_5S_2$	Chloroacetyl-*l*-cystine	*N* HCl	*4.63*	17	−169.2	(505)
$C_8H_{16}N_2O_4S_2$	Cystine dimethyl ester	EtOH	*1.01*	20	49.89	(20)
$C_9H_{10}BrNO_2S$	Bromophenylcysteine	dil. NaOH	*9*		−3.7	(96)
$C_{10}H_{14}Cl_2N_2O_6S_2$	Dichloroacetyl-*l*-cystine	EtOH	*10.1*	20	−120.3	(505)
		EtOH	*9.1*		−125.9	(20)
$C_{10}H_{14}Br_2N_2O_6S_2$	Dibromoacetyl-*l*-cystine	EtOH	*1.48*	20	−107.97	(20)
$C_{10}H_{14}I_2N_2O_6S_2$	Diiodoacetyl-*l*-cystine	EtOH	*2.62*	20	−95.35	(20)
$C_{10}H_{22}Cl_2N_2O_4S_2$	Diethylcystine dihydrochloride	H_2O	*3.61*	20	−47.96	(20)
$C_{11}H_{12}BrNO_3S$	Bromophenylmercapturic acid	EtOH	*12–15*		−6.7	(96)
		NaOH	*25*		6.4	

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* $(CH_3)_3N^+.CH(CH_3).COO^-$.

Cystine and cysteine and derivatives.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{11}H_{13}NO_3S$	Phenylmercapturic acid*	EtOH	*20*		−9.3	(96)
	Sodium salt	H_2O	*8*		4.2	(96)
$C_{12}H_{18}Br_2N_2O_6S_2$	Di-*d*-α-bromopropionyl-*l*-cystine	EtOH	*2.13*	20	−96.96	(20)
	Di-*l*-α-bromopropionyl-*l*-cystine	EtOH	*2.03*	20	−133.23	
$C_{12}H_{22}BrN_2O_5S_2$	Mono-*d*-α-bromoisohexoyl-*l*-cystine†	0.273*N* NaOH	*5.08*	21	−130.2	(505)
$C_{18}H_{30}Br_2N_2O_6S_2$	Di-*d*-α-bromoisohexoyl-*l*-cystine	EtOH	*10.0*	20	−133.7	(505)
$C_{26}H_{24}N_2O_8S_4$	Di-β-naphthalenesulfonyl-*l*-cystine	*N* NaOH	*1.98*	20	−82.88	(20)
	Aminobutyric acid and derivatives					
$C_4H_7N_3O_2$	*l*-α-Triazobutyric acid	Et_2O	14.29		−63.3	(607)
$C_4H_9NO_2$	*l*-β-Aminobutyric acid	H_2O	*9.961*	20	−35.2	(545)
$C_5H_9NO_3$	Formyl-*l*-aminobutyric acid	H_2O	*4.56*	20	28.0	(19)
$C_6H_{11}N_3O_2$	Ethyl *l*-α-triazobutyrate	Et_2O	15.84		−48.1	(607)
$C_8H_{15}NO_4$	*d*-β, β-Iminodibutyric acid $[NH(CH_3CH.CH_2.COOH)_2]$	H_2O	*10*	20	65.3	(1864)
$C_{10}H_{20}ClNO_4$	Dimethyl β, β-iminodibutyrate hydrochloride	MeOH	*10.31*	20	41.6	(1864)
	Valine (α-aminovaleric acid), its isomers and derivatives					
$C_5H_{11}NO_2$	*l*-Valine $[(CH_3)CH.CH(NH_2).COOH]$	20% HCl	*3.72*	20	−28.4	(472)
$C_5H_{11}NO_2$	*l*-α-Amino-α-methylbutyric acid	H_2O	5	20	−9.10	(409, 413, 414)
		20% HCl	3.67		−6.11	
$C_5H_{11}NO_2$	*d*-γ-Aminovaleric acid	H_2O	*9.986*	20	12.0	(507)
$C_6H_{11}NO_3$	Formyl-*l*-valine	EtOH	*11.2*	20	−13	(472)
		H_2O		20	−16.9	
$C_7H_{12}ClNO_3$	Chloroacetyl-*d*-valine	EtOH	*10.1*	20	15.8	(544)
$C_8H_{14}BrNO_3$	*d*-α-Bromopropionyl-*d*-valine	EtOH	*9.97*	20	21.0	(544)
$C_{10}H_{18}BrNO_3$	*l*-α-Bromoisovaleryl-*d*-valine	EtOH	*9.81*	20	−22.7	(544)
$C_{11}H_{20}BrNO_3$	*d*-α-Bromoisohexoyl-*d*-valine	EtOH	*10.2*	20	24.3	(544)
$C_{12}H_{15}NO_3$	Benzoyl-*d*-γ-aminovaleric acid	EtOH	*10.00*	20	−21.9	(507)
$C_{12}H_{16}N_2O_3$	*l*-Valinephenylcarbamide	EtOH	*4.05*	20	−19.02	(472)
	n-Leucine (α-amino-n-caproic acid) and derivatives					
$C_6H_{13}NO_2$	*l*-α-Amino-*n*-hexoic acid	20% HCl	*4.56*	20	−22.99	(1383); *cf.* (508, 1908.5)
$C_7H_{13}NO_3$	*l*-Formyl-α-amino-*n*-hexoic acid	EtOH	*11.4*	20	−17.56	
$C_7H_{15}N_3O_2$	*d*-α-Guanidinoisohexoic acid	*N* HCl	*8.12*	20	4.54	(1766)
$C_{13}H_{17}NO_3$	*l*-Benzoyl-α-amino-*n*-hexoic acid	H_2O	*8.21*	20	−21.9	(508)
	d- and l-Leucine and derivatives					
$C_6H_{13}NO_2$	*d*-Leucine$[(CH_3)_2CH.CH_2.CH(NH_2).COOH]$; (1259, 1401.5, 1901, 1902)	20% HCl	*3.66*	20	−15.6	(556); *cf.* (495)
	l-Leucine	21% HCl	*4.73*	20	−16.91	(467.5)
$C_7H_{13}NO_3$	Formyl-*d*-leucine	EtOH	10	20	18.8	(556)
$C_7H_{15}NO_2$	*l*-*N*-Methylleucine	H_2O	*2.98*	21	20.76	(523)
$C_7H_{16}ClNO_2$	*l*-*N*-Methylleucine hydrochloride	H_2O	*9.18*	19	21.57	(523)
$C_8H_{14}ClNO_3$	Chloroacetyl-*l*-leucine	EtOH	*8.95*	20	−14.4	(549)
$C_9H_{16}BrNO_3$	*d*-Bromopropionyl-*l*-leucine	*N* NaOH	*3.06*	20	−5.87	(475)
$C_{12}H_{17}NO_4S$	Benzenesulfonyl-*d*-leucine	Alk.	*9.94*	20	−39	(468)
$C_{12}H_{22}BrNO_3$	*d*-α-Bromoisohexoyl-*l*-leucine	AcOEt	*10*	20	16.2	(473)
$C_{12}H_{22}BrNO_3$	*l*-α-Bromoisohexoyl-*l*-leucine	AcOEt	*10.3*	20	−34.97	(478)
		0.5*N* NaOH	*9.95*	20	−53.22	
	d-α-Bromoisohexoyl-*d*-leucine	AcOEt	*11.0*	20	34.70	
		0.5*N* NaOH	*9.97*	20	52.46	
$C_{13}H_{17}NO_3$	Benzoyl-*l*-leucine	0.5*N* NaOH	*8.79*	20	6.59	(467.5)
$C_{13}H_{19}NO_4S$	*p*-Toluenesulfonyl-*l*-leucine	EtOH	*8.95*	20	4.50	(523)
$C_{14}H_{21}NO_4S$	*p*-Toluenesulfonyl-*l*-*N*-methylleucine	EtOH	*9.90*	18	−21.12	(523)
	Other homologues of glycine					
$C_{24}H_{41}NO_2$	*d*-α-Anilinostearic acid $(C_{16}H_{33}.CH(NH.C_6H_5).COOH)$	Py	3.10	19	34.7	(1202)
		EtOH	0.604	40	18.6	
	Arginine and histidine					
$C_6H_9N_3O_2$	*l*-Histidine, glyoxaline-4-alanine‡	H_2O	3.36	22	−37.7	(1749)
	d-Histidine	H_2O	2.68	23	39.3	(1749)

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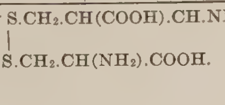
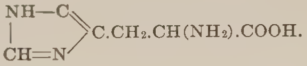
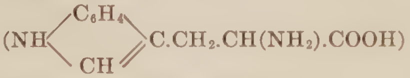
* Acetylphenylcysteine $(C_6H_5.S.CH_2.CH(NHCO.CH_3)COOH)$.

† 
$\begin{array}{l} S.CH_2.CH(COOH).CH.NH.CO.CHBr.C_4H_9 \\ | \\ S.CH_2.CH(NH_2).COOH. \end{array}$

‡ 
$\begin{array}{l} NH-C \\ | \qquad \rangle C.CH_2.CH(NH_2).COOH. \\ CH=N \end{array}$

Arginine and histidine.—(Continued)

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_6H_{14}N_4O_2$	*l*-Arginine, α-amino-δ-guanidino-*n*-valeric acid*					(1780)
$C_6H_{15}ClN_4O_2$	*l*-Arginine hydrochloride			20	−20.51	(1780)
	d-Arginine hydrochloride	H_2O	8	19	33.1	(1909)
$C_6H_{15}N_5O_5$	*d*-Arginine nitrate	H_2O	10	19	28.75	(1909)
$C_{10}H_{15}N_3O_8$	*d*-Histidine *d*-hydrogen tartrate	H_2O	3.688	28	13.3	(1749)
	l-Histidine *l*-hydrogen tartrate	H_2O	4.530	25	−12.1	(1749)
	l-Histidine *d*-hydrogen tartrate	H_2O	5.740	27	17.4	(1749)
	Tryptophane					
$C_{11}H_{12}N_2O_2$	Tryptophane	*N* NaOH	*11.4*	20	6.12	(15)
	 $(NH\langle^{C_6H_4}_{CH}\rangle C.CH_2.CH(NH_2).COOH)$	*N* NaOH	*9.12*	20	6.52	(4)
		H_2O	*0.494*	20	−30.33	(4)
$C_{13}H_{13}ClN_2O_3$	Chloroacetyl-*d*-tryptophane	EtOH	*6.88*	20	32.9	(16); *cf.* (3)
$C_{13}H_{13}IN_2O_3$	Iodoacetyl-*l*-tryptophane	EtOH	*4.92*	20	31.3	(3)
$C_{14}H_{18}N_2O_2$	Hypaphorine (the betaine of tryptophane)†	H_2O	1.66		94.7	(1791)
$C_{17}H_{21}BrN_2O_3$	*d*-α-Bromoisohexoyl-*d*-tryptophane	EtOH	*11.2*	20	27.1	(16)
	Phenylglycine and derivatives					
$C_8H_9NO_2$	*l*-α-Aminophenylacetic acid	H_2O		20	−90.35	(413, 414); *cf.* (142)
	$[C_6H_5.CH(NH_2).COOH]$	10% HCl	*3.67*	20	−144.95	
		0.31*N* HCl	*7.19*	20	−157.8	(557)
$C_9H_9NO_3$	*l*-Formylaminophenylacetic acid	EtOH	*4*	20	−259.8	(557)
$C_{10}H_{14}ClNO_2$	Ethyl *l*-aminophenylacetate hydrochloride	H_2O	*5.02*	20	88.95	(557)
$C_{14}H_{13}NO_2$	*l*-Phenylanilinoacetic acid	Me_2CO	1.47		−117.9	
		EtOH	1.02		−111.7	
		AcOEt	2.06		−106.8	
$C_{15}H_{14}N_2O_3$	*l*-α-Aminophenylacetic acid phenylurea	0.5*N* NaOH	*5.15*	20	−129.27	(413, 414)
	Phenylalanine and derivatives					
$C_9H_{11}NO_2$	*d*-Phenylalanine $[C_6H_5.CH_2.CH(NH_2).COOH]$	H_2O	*1.75*	20	35.14	(546)
		H_2O	*2.03*	16	35.08	(527)
		H_2O	*3.48*	20	6.86	
		20% HCl	*2.01*	20	34.56	(409, 413, 414)
$C_9H_{11}NO_4$	*l*-3, 4-Dihydroxyphenylalanine	$HCl.H_2O$	*3.81*	15	−12.74	(2132)
$C_{10}H_{11}NO_3$	Formyl-*d*-phenylalanine	EtOH	*4.2*	20	−75.43	(546)
$C_{10}H_{13}NO_2$	*N*-Methyl-*d*-phenylalanine	0.1*N* NaOH	*1.58*	18	−48.22	(523)
		N HCl	*5.86*	20	−17.7	
$C_{11}H_{12}ClNO_3$	*N*-Chloroacetyl-*l*-phenylalanine	EtOH	*3.64*	20	51.8	(546)
$C_{11}H_{16}ClNO_2$	*l*-Phenylalanine ethyl ester hydrochloride	H_2O	*3.14*	20	−7.6	(546)
$C_{16}H_{15}NO_3$	Benzoyl-*d*-phenylalanine	1.4% KOH	*6.36*	20	−17.1	(527)
$C_{16}H_{17}NO_4S$	*p*-Toluenesulfonyl-*d*-phenylalanine	Me_2CO	*7.40*	20	2.30	(523)
$C_{17}H_{19}NO_4S$	*p*-Toluenesulfonyl-*d*-methylphenylalanine	Me_2CO	*7.46*	20	32.63	(523)
		0.5*N* NaOH	6.39	20	−8.58	
$C_{16}H_{17}NO_2$	*N*-Benzylphenylalanine	0.4*N* NaOH	*5.9*	18	17.58	(524)
	Tyrosine (β-p-hydroxyphenylalanine) and derivatives					
$C_9H_9I_2NO_3$	2, 5-Diiodo-*l*-tyrosine	25% NH_3	*4.73*	20	2.27	(11)
		4% HCl	*4.83*	20	2.89	
$C_9H_{10}N_2O_5$	*l*-3-Nitrotyrosine	4% HCl	5.29	16	−16.2	(1913)
$C_9H_{11}NO_3$	Tyrosine $[HO.C_6H_4.CH_2.CH(NH_2)COOH]$	21% HCl	4.5	16.2	−7.98	(1401); *cf.* (1257, 1259, 1901)
		11.6% KOH	5.8	20.5	−9.01	
		11.6% KOH	11.5	16.1	8.86	
$C_9H_{12}N_2O_2$	*l*-Tyrosineamide	H_2O	*6.07*	20	19.49	(1120)
$C_{10}H_{11}NO_4$	Formyl-*l*-tyrosine	EtOH	*5.37*	20	84.9	(476)
$C_{11}H_{15}NO_3$	*l*-Tyrosine ethyl ester	EtOH	*4.85*	20	20.4	(468)
$C_{12}H_{13}NO_6$	Formyl-*l*-tyrosine methylcarbonate	EtOH	*5.3*	20	66.7	(480)
$C_{13}H_{14}ClNO_6$	Chloroacetylcarbomethoxy-*l*-tyrosine	EtOH	*9.98*	20	48.7	(480); *cf.* (481)

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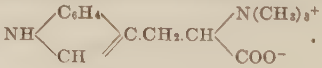
* $NH_2.C(:NH)NH(CH_2)_3.CH(NH_2).COOH$.

†  $NH\langle^{C_6H_4}_{CH}\rangle C.CH_2.CH\langle^{N(CH_3)_3^+}_{COO^-}$.

Tyrosine (β-p-hydroxyphenylalanine) and derivatives.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{16}H_{15}NO_4$	Benzoyl-*l*-tyrosine	8% NaOH	*8.04*	20	19.25	(467)
$C_{16}H_{17}NO_5S$	*O*-*p*-Toluenesulfonyl-*l*-tyrosine	*N* HCl	*6.33*	17	−4.58	(486.5)
		N NaOH	*6.17*	17	−11.68	
	N-*p*-Toluenesulfonyl-*l*-tyrosine	EtOH	*7.24*	21	−0.85	(523)
$C_{18}H_{21}NO_5S$	*N*-*p*-Toluenesulfonyl-*l*-tyrosine ethyl ester	EtOH	*7.27*	17	6.76	(523)
$C_{18}H_{21}NO_5S$	*N*-*p*-Toluenesulfonyl-*O*, *N*-dimethyltyrosine	EtOH	*6.83*	20	−26.75	(523)
$C_{24}H_{25}NO_7S_2$	Di-(*p*-Toluenesulfonyl)-*N*-methyltyrosine	EtOH	*3.11*	21	−25.34	(486.5)
	DIAMINOMONOCARBOXYLIC ACIDS					
$C_3H_8N_2O_2$	*d*-Diaminopropionic acid, sodium salt from dihydrochloride	*N* HCl	*4.84*	20	25.0	(1040)
$C_3H_{10}Cl_2N_2O_2$	*l*-Diaminopropionic acid, sodium salt from dihydrochloride	*N* NaOH	*9.87*	20	25	
	All calculated on dihydrochloride	*N* NaOH	*11.8*		−1.8	(517)
		2*N* NaOH	*6.15*	20	−8.1	
$C_{17}H_{15}N_2O_4Na$	Dibenzoyl-*d*-diaminopropionic acid, sodium salt	H_2O	*10*	20	−35.76*	(517)
	MONOAMINODICARBOXYLIC ACIDS					
	Aspartic acid and derivatives					
$C_4H_7NO_4$	*d*-Aspartic acid					
$C_4H_8N_2O_3$	$[CH_2(COOH).CH(NH_2)\ COOH]$	dil.NaOH	*0.366*	20	−2.48	(1038)
	l-Asparagine $[C_2H_3(NH_2)COOH.CO.NH_2]$	H_2O	*1.961*	34	−6.7	(1332)
$C_5H_9NO_4$	*l*-Methylaspartic acid	H_2O	0.5525		−15.44	(1318)
		0.055*N* HCl	0.5525		−22.6	
		0.158*N* HCl	0.5525		−28.9	
		1.57*N* HCl	0.5525		−30.8	
		0.25*N* NaOH	0.5525		−29.8	
$C_7H_{12}N_2O_4$	Methyl *l*-acetylasparagate	H_2O	*2.13*	19	−41.14	(1040)
$C_8H_{15}NO_4$	*l*-Diethyl aspartate		1.089_4^{17}	20	−9.46	(468)
$C_{10}H_{17}BrN_2O_4$	*d*-α-Bromoisohexoyl-*l*-asparagine	*N* NaOH	*5.7*	20	15.7	(520); *cf.*, (519)
	l-α-Bromoisohexoyl-*l*-asparagine	*N* NaOH	*5.7*	20	−30.1	
$C_{12}H_{12}BrNO_5$	Phenylbromoacetylaspartic acid $[C_6H_5.CHBr.CO.NH.CH(COOH).CH_2.COOH]$	0.161*N* NaOH	*9.5*	20	3.6	(554)
		0.183*N* NaOH	*9.5*	20	3.6	(535)
$C_{12}H_{13}BrN_2O_4$	Phenylbromoacetylasparagine	0.5*N* NaOH	*12.66*	20	3.33	(335, 554)
$C_{16}H_{20}BrNO_5$	Diethyl phenylbromoacetylaspartate $[C_6H_5.CHBr.CO.NH.CH(CO.OC_2H_5)CH_2.CO.OC_2H_5]$	EtOH	*5.21*	20	−13.40	(554)
		EtOH	*5.21*	20	−13.23	(535)
	Glutamic acid and derivatives					
$C_5H_7NO_3$	*d*-Pyroglutamic acid	H_2O	2.665	25	7	(1862)
$C_5H_9NO_4$	*d*-Glutamic acid $[HO.CO.CH_2.CH_2.CH(NH_2)COOH]$	H_2O	2	21	10.2	(1862)
	(Supersaturated)	H_2O	4	23	10.6	
		dil. HNO_3	4	22	29.9	
	Calcium salt	H_2O	5.03	20	−3.7	(1862)
$C_5H_{10}ClNO_4$	*d*-Glutamic acid hydrochloride	H_2O	4	21	20.4	(1862)
$C_7H_{10}ClNO_5$	Chloroacetyl-*d*-glutamic acid	H_2O	*9.93*	20	−13.5	(521)
$C_9H_{14}N_2O_4$	Diethyl α-diazoglutarate	Et_2O	50	20	2.70	(1238)
$C_9H_{17}NO_4$	*d*-Diethyl glutamate		1.0737_4^{17}	20	7.34	(468)
	POLYPEPTIDES†					
$C_5H_{10}N_2O_3$	*d*-Alanylglycine	H_2O	*10*	18	50.3	(479)
$C_6H_{11}N_3O_4$	Glycylasparagine	H_2O	*7*	20	−6.4	(519)
$C_6H_{12}N_2O_3$	*d*-Alanyl-*d*-alanine	H_2O	*4.93*	20	−21.6	(471)
	l-Alanyl-*d*-alanine	H_2O		20	−68.5	(536)
	d-Alanyl-*l*-alanine	H_2O	*7.42*	20	68.94	(537)
$C_7H_{10}N_2O_2$	*l*-Prolylglycyl anhydride‡	H_2O	*7.45*	20	−216.2	(540)
$C_7H_{11}BrN_2O_4$	*d*-α-Bromopropionylglycylglycine	Alk.	8.6	20	29.7	(479)
$C_7H_{11}ClN_2O_4$	Chloroacetyl-*d*-alanylglycine	H_2O	*5*	18	−53.4	(479)
$C_7H_{12}N_2O_2$	Glycyl-*d*-valine anhydride	AcOH	*10.1*	20	20.8	(544)
		H_2O	*1.99*		32.7	
		EtOH	*0.537*		41	
$C_7H_{12}N_2O_5$	Glycyl-*d*-glutamic acid	H_2O	*10.0*	20	−6.3	(521)

* Calculated on weight of acid.

† This table includes polypeptides which contain two or more asymmetric carbon atoms (IB_2, etc.) and also those which contain isoleucine groups (IC).

‡ These derivatives were not made from optically pure substances, but this is, apparently, the only work on such compounds.

Polypeptides.—(*Continued*)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_7H_{13}N_3O_4$	Glycyl-*d*-alanylglycine	H_2O	4.31	20	−64.3	(479)
$C_7H_{13}N_3O_4$	*d*-Alanylglycylglycine	H_2O	9.71	20	31.4	(479)
$C_7H_{13}N_3O_4$	*l*-Alanylglycylglycine	H_2O	10.4	20	−29.2	(473)
$C_7H_{14}N_2O_3$	*d*-Valylglycine	H_2O	10.4	20	93.6	(544)
		10% HCl	1.78	20	39.4	
$C_7H_{14}N_2O_3$	Glycyl-*d*-valine	H_2O	9.9	20	−19.7	(544)
		HCl aq.	9.97	20	−10.5	
		NaOH	9.27	20	−6.9	
$C_8H_{14}N_2O_2$	Glycyl-*d*-isoleucine anhydride	AcOH	2.85	20	−26.05	(13)
$C_8H_{14}N_2O_2$	*d*-Alanyl-*d*-valine anhydride	AcOH	10.0	20	−29.3	(544)
$C_8H_{14}N_2O_2$	*l*-Leucylglycine anhydride	H_2O	1.85	20	32.95	(473)
$C_8H_{16}N_2O_3$	*d*-Alanyl-*d*-valine	N HCl	9.9	20	−1.9	(544)
		N NaOH	9.48		−4.5	
$C_8H_{16}N_2O_3$	Glycyl-*l*-leucine	H_2O	6.65	20	−34.9	(549)
		H_2O	3.093	20	−35.23	(9)
		EtOH	10.21	20	−13.82	
$C_8H_{16}N_2O_3$	Glycyl-*d*-isoleucine	H_2O	4.2	20	−14.7	(13)
$C_8H_{16}N_2O_3$	*d*-Isoleucylglycine	H_2O	5.9	20	33.59	(13)
$C_8H_{16}N_2O_3$	*l*-Leucylglycine	H_2O	8.6	20	85.5	(473)
		EtOH	2.912	20	−63.39	(9)
		H_2O	1.998	20	−84.56	
$C_8H_{16}N_2O_3$	*d*-Leucylglycine	H_2O	3.453	20	37.33	
$C_9H_{16}N_2O_2$	*d*-Alanyl-*d*-isoleucine anhydride	AcOH	5.85	20	−16.6	(13)
$C_9H_{16}N_2O_2$	*l*-Leucyl-*d*-alanine anhydride	AcOH	9.10	20	−29.0	(473)
$C_9H_{16}N_4O_5$	*d*-Alanyldiglycylglycine	H_2O	3.19	20	27	(14)
$C_9H_{16}N_4O_5$	*d*-Alanylglycylglycylglycine	H_2O	8.98	20	22.4	(17)
$C_9H_{18}N_2O_3$	*d*-Alanyl-*d*-isoleucine	N HCl	3.72	20	6.1	(13)
		N NaOH	4.81	20	−297	(13)
$C_9H_{18}N_2O_3$	*d*-Alanyl-*l*-leucine	H_2O	1.761	20	−16.96	(9)
		H_2O	8.78	20	−17.21	(475)
	l-Leucyl-*d*-alanine	MeOH	3.829	20	19.84	(9)
		MeOH	4.83	20	23.7	(473)
$C_{10}H_{17}BrN_2O_4$	*d*-Bromoisocaproylglycylglycine	EtOH	4.36	20	47.01	(10)
		H_2O	1.45	20	31.17	
		0.1N NaOH	2.67	20	26.24	
$C_{10}H_{18}N_2O_2$	*trans*-Valine anhydride	AcOH	2.2		±0	(544)
$C_{10}H_{18}N_4O_6S_2$	Diglycyl-*l*-cystine	H_2O	4.00	20	−99.91	(20)
$C_{10}H_{19}N_3O_4$	*d*-Leucyl-*l*-asparagine	H_2O	4.78	20	−53.6	(520)
	l-Leucyl-*l*-asparagine	H_2O	5.57	20	17.8	
$C_{10}H_{19}N_3O_4$	*l*-Leucylglycylglycine	H_2O	4.53	20	44.79	(10)
$C_{10}H_{20}N_2O_3$	*l*-Valyl-*d*-valine	H_2O	10.0	20	−74.0	(544)
$C_{11}H_{12}I_2N_2O_4$	Glycyl-2, 4-diiodo-*l*-tyrosine	25% NH_3	5.07	20	52.69	(11)
$C_{11}H_{12}N_2O_2$	Glycyl-*l*-phenylalanine anhydride	AcOH	2.57	20	100.5	(546)
$C_{11}H_{14}N_2O_3$	*l*-Phenylalanylglycine	H_2O	2.41	20	54.20	(546)
$C_{11}H_{14}N_2O_3$	Glycyl-*l*-phenylalanine	H_2O	2.05	20	41.4	(546)
$C_{11}H_{18}N_2O_2$	*l*-Prolylleucine anhydride*	EtOH	3.06	20	−143.4	(540)
$C_{11}H_{19}BrN_2O_4$	*d*-α-Bromopropionyl-*l*-leucylglycine	EtOH	5.095	20	−24.84	(9)
$C_{11}H_{19}BrN_2O_4$	*d*-α-Bromoisocaproyl-*d*-alanylglycine	EtOH	4.918	20	−2.52	(9)
$C_{11}H_{19}BrN_2O_4$	*d*-α-Bromopropionylglycyl-*l*-leucine	EtOH	7.720	20	14.71	(9)
$C_{11}H_{19}BrN_2O_4$	*d*-α-Bromoisohexoylglycyl-*d*-alanine	EtOH	10.2	20	20.4	(549)
$C_{11}H_{19}ClN_2O_4$	Chloroacetyl-*l*-leucyl-*d*-alanine	EtOH	4.583	20	−41.52	(9)
$C_{11}H_{20}N_2O_2$	*l*-Leucyl-*d*-valine anhydride	AcOH	5.01	20	−50.2	(544)
$C_{11}H_{20}N_2O_5$	*l*-Leucyl-*d*-glutamic acid	N HCl	8.20	20	10.5	(476)
$C_{11}H_{21}N_3O_4$	*d*-Alanyl-*l*-leucylglycine	H_2O	2.092	28	−30.43	(9)
$C_{11}H_{21}N_3O_4$	*d*-Alanylglycyl-*l*-leucine	H_2O	2.131		−11.20	(9)
$C_{11}H_{21}N_3O_4$	*l*-Leucylglycyl-*d*-alanine	H_2O	9.89	20	20.3	(549)
$C_{11}H_{22}N_2O_3$	*l*-Leucyl-*d*-valine	H_2O	10.0	20	18.0	(544)
$C_{12}H_{14}I_2N_2O_4$	*dl*-Alanyl-3, 5-diiodo-*l*-tyrosine	25% NH_3	6.48	20	47.23	(12)
$C_{12}H_{14}I_2N_2O_4$	*d*-Alanyl-3, 5-diiodo-*l*-tyrosine	25% NH_3	7.95	20	62.88	(14)
$C_{12}H_{15}N_3O_4$	Phenylglycylasparagine	0.334N NaOH	6.015	20	−2.3	(554)
$C_{12}H_{16}N_2O_4$	*d*-Alanyl-*l*-tyrosine	H_2O	2.04	20	43.14	(14)
$C_{12}H_{20}BrN_3O_5$	α-Bromoisohexoyldiglycylglycine	0.3N NaOH	8.54	20	31.98	(473)
$C_{12}H_{20}N_4O_3$	*l*-Leucyl-*l*-histidine	H_2O	5.06	20	32.06	(496)

* These derivatives were not made from optically pure substances, but this is, apparently, the only work on such compounds.

POLYPEPTIDES.—(*Continued*)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{12}H_{22}N_2O_2$	*l*-Leucine anhydride	AcOH	*8.09*	20	−42.8	(473)
$C_{12}H_{22}N_2O_2$	*d*-Leucine anhydride	AcOH	*8.70*	20	48.67	(478)
$C_{12}H_{22}N_4O_5$	Glycyl-*l*-asparaginyl-*l*-leucine	*N* HCl	*5.2*	20	−46.5	(520)
$C_{12}H_{22}N_4O_5$	*l*-Leucyldiglycylglycine	H_2O	*9.54*	20	45.85	(473)
$C_{12}H_{22}N_4O_6S_2$	Di-*l*-alanyl-*l*-cystine	*N* HCl	*1.02*	20	−227.9	(20); *cf.* (552)
$C_{12}H_{24}N_2O_3$	*d*-Leucyl-*l*-leucine	*N* HCl	*9.83*	20	−67.97	(478)
	l-Leucyl-*d*-leucine	*N* HCl	*9.70*	20	68.95	
	d-Leucyl-*d*-leucine	*N* NaOH	*11.9*	20	13.16	
	l-Leucyl-*l*-leucine	*N* NaOH	*4.33*	20	−13.43	(473)
	l-Leucyl-*d*-isoleucine	*N* HCl	*2.67*	20	20.17	(13)
$C_{13}H_{13}NO$	*l*-2-β-Hydroxy-β-phenylethylpyridine	$CHCl_3$	13.2	25	−36.44	(1267)
$C_{13}H_{15}N_3O_3$	Glycyl-*d*-tryptophane	*N* HCl	*9.58*	20	−21.45	(16)
$C_{13}H_{15}N_3O_3$	Tryptophanylglycine	H_2O	*4.43*	20	78.7	(16)
$C_{14}H_{17}N_3O_3$	*d*-Alanyl-*d*-tryptophane, copper salt	H_2O	*6.11*	20	18.65	(16)
$C_{14}H_{15}N_3O_2$	*dl*-Alanyl-*l*-tryptophane anhydride	AcOH	*9.47*	20	87.0	(3)
$C_{14}H_{17}BrN_2O_5$	*d*-α-Bromopropionylglycyltyrosine	H_2O	*4.14*	20	5.06	(476)
$C_{14}H_{19}N_3O_5$	*d*-Alanylglycyl-*l*-tyrosine	H_2O	*4.58*	20	41.9	(476)
$C_{14}H_{19}N_3O_5$	Glycyl-*d*-alanyl-*l*-tyrosine	H_2O	*4.5*	20	−4.83	(14)
$C_{14}H_{23}BrN_4O_6$	*d*-Bromoisocaproyltriglycylglycine	H_2O	*1.29*	20	22.55	(10)
		0.1*N* NaOH	*3.18*	20	25.47	
$C_{14}H_{24}N_6O_7$	*l*-Alanyldiglycyl-*l*-alanylglycylglycine	H_2O	*7.86*	21	13	(473)
$C_{14}H_{25}BrN_2O_4$	*d*-α-Bromoisohexoylglycyl-*l*-leucine	EtOH	*9.90*	20	29.1	(549)
$C_{14}H_{25}N_5O_6$	*l*-Leucyltriglycylglycine	H_2O	*3.19*	20	28.14	(10)
$C_{15}H_{22}N_2O_4$	*l*-Leucyl-*l*-tyrosine	H_2O	*2.11*	20	10.37	(14)
$C_{15}H_{16}N_2O_5S$	β-Naphthalenesulfo-*d*-alanylglycine	0.47*N* NaOH	*5.18*		−63.71*	(492)
$C_{16}H_{19}N_3O_5$	*l*-Tryptophanyl-*d*-glutamic acid	H_2O	*4.33*	20	34.35	(2)
$C_{16}H_{22}N_4O_6$	Glycyl-*d*-alanylglycyl-*l*-tyrosine	H_2O	*9.72*	20	4.0	(479)
$C_{17}H_{23}N_3O_3$	*l*-Leucyl-*d*-tryptophane	*N* HCl	*7.16*	20	4.48	(16)
$C_{18}H_{29}BrN_6O_8$	*d*-α-Bromoisocaproylpentaglycylglycine	0.1*N* NaOH	*3.31*	20	18.19	(10)
$C_{18}H_{31}BrN_4O_6$	*d*-α-Bromoisohexoyltriglycyl-*l*-leucine	*N* NaOH	*7.12*	20	23.5	(549)
$C_{18}H_{31}N_7O_8$	*l*-Leucylpentaglycylglycine	*N* NaOH	*4.97*	20	5.94	(10)
$C_{18}H_{33}N_5O_6$	*l*-Leucyltriglycyl-*l*-leucine	H_2O	*2.5*	20	21.3	(549)
$C_{18}H_{34}N_4O_6S_2$	Di-*l*-leucyl-*l*-cystine	*N* HCl	*2.56*	20	−136.6	(505)
$C_{19}H_{24}BrN_3O_4$	*d*-α-Bromoisohexoylglycyl-*d*-tryptophane	EtOH	*11.4*	20	54.47	(16)
$C_{19}H_{26}N_4O_4$	*l*-Leucylglycyl-*d*-tryptophane	*N* HCl	*8.16*	20	32.30	(16)
$C_{20}H_{32}BrN_7O_9$	*d*-α-Bromoisohexoylhexaglycylglycine	*N* NaOH	*7.94*	20	3.55	(475)
$C_{20}H_{34}N_8O_9$	*l*-Leucylhexaglycylglycine	*N* NaOH	*6.32*	20	6.34	(475)
$C_{21}H_{20}N_2O_6S$	β-Naphthalenesulfoglycyltyrosine	0.34*N* NaOH	*5.05*	20	17.9*	(492)
$C_{21}H_{29}BrN_4O_7$	*d*-α-Bromoisohexoyltriglycyl-*l*-tyrosine	H_2O	*1.23*	20	28.7	(476)
$C_{21}H_{31}N_5O_7$	*l*-Leucyltriglycyl-*l*-tyrosine	H_2O	*4.82*	20	36.5	(476)
$C_{22}H_{30}N_4O_6$	*l*-Leucyl-*l*-tryptophanyl-*d*-glutamic acid	*N* HCl	4.03	20	17.4	(2)
$C_{22}H_{36}Cl_2N_4O_8S_2$	Dichloroacetyldi-*l*-leucyl-*l*-cystine	EtOH	*1.58*	20	−102.8	(20)
$C_{22}H_{36}Br_2N_4O_8S_2$	Dibromoacetyl-di-*l*-leucyl-*l*-cystine	EtOH	*1.69*	20	−55.81	(20)
	Di-*d*-α-bromoisocaproyl-diglycyl-*l*-cystine	EtOH	*2.49*	20	−21.76	
$C_{22}H_{40}N_6O_8S_2$	Di-*l*-leucyldiglycyl-*l*-cystine	H_2O	*0.77*	20	−72.24	(20)
		N HCl		20	−75.45	
$C_{22}H_{40}N_6O_8S_2$	Diglycyl-di-*l*-leucyl-*l*-cystine	H_2O	*0.728*	20	−108.86	(20)
		N HCl	*0.837*	20	−134.46	
$C_{24}H_{40}Br_2N_4O_8S_2$	Di-*d*-α-bromoisocaproyl-di-*d*-alanyl-*l*-cystine	EtOH	1.88	20	−54.53	(20)
$C_{30}H_{30}N_4O_{10}S_4$	Di-β-naphthalenesulfono-diglycyl-*l*-cystine	*N* NaOH	*0.72*	20	−91.8	(20)
$C_{30}H_{49}BrN_{10}O_{12}$	*d*-α-Bromoisocaproyltriglycyl-*l*-leucylpentaglycylglycine	0.1*N* NaOH	*4.34*	20	7.34	(10)
$C_{30}H_{51}N_{11}O_{12}$	*l*-Leucyltriglycyl-*l*-leucylpentaglycylglycine	NaOH	*1*	20	−6	(10)
$C_{42}H_{69}BrN_{14}O_{16}$	*d*-α-Bromoisocaproyltriglycyl-*l*-leucyltriglycyl-*l*-leucylpentaglycylglycine	0.1*N* NaOH	*3.75*	20	−4	(10)
$C_{42}H_{71}N_{15}O_{16}$	*l*-Leucyltriglycyl-*l*-leucyltriglycyl-*l*-leucylpentaglycylglycine	0.1*N* NaOH	*0.83*	20	−9.63	(10)
$C_{54}H_{89}BrN_{18}O_{20}$	*d*-α-Bromoisocaproyltriglycyl-*l*-leucyltriglycyl-*l*-leucyltriglycyl-*l*-leucylpentaglycylglycine	0.1*N* NaOH	2.5	20	−8	(10)
$C_{54}H_{91}N_{19}O_{20}$	*l*-Leucyltriglycyl-*l*-leucyltriglycyl-*l*-leucyltriglycyl-*l*-leucylpentaglycylglycine	0.1*N* NaOH	*0.95*	20	−8.42	(10)

* For white light.

IB$_2$. The Molecule Contains Two Asymmetric Carbon Atoms Which Are Attached Each to Two Other Carbon Atoms

ALCOHOLS AND AMINES

POLYHYDRIC ALCOHOLS (SUGARS AND DERIVATIVES)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_4H_6O_4$	*d*-Erythronic acid lactone	H_2O?	8.04	20	−73.3	(1805)
$C_4H_8O_4$	*l*-Erythrose	H_2O	*5.29*	20	21.5*	(1806)
$C_4H_{10}O_4$	*l*-Erythritol ($HO.CH_2.CHOH.CHOH.CH_2.OH$)	H_2O	6		4.3	(1372)
		EtOH	1.5		−15	
		H_2O	*20*		−4.25	(1374)
		90% EtOH	*20*		−10.50	
$C_5H_{11}NO_4$	Pentane-3, 4, 5-triolal oxime ($HO.CH_2.(CHOH)_2.CH_2.CH:NOH$)	H_2O	4.2		10.6	(1067)
	Pentane-1, 4, 5-triol-3-one oxime ($HO.CH_2.CHOH.C(NOH).CH_2.CH_2OH$)	H_2O	3.28		11.8	
$C_6H_{11}ClN_2O_3$	Trihydroxypropylpyrazole hydrochloride§	H_2O	*9.74*		−5.6†	(668)
$C_{10}H_{14}N_2O_4$	*d*-Erythronic acid phenylhydrazide	H_2O?	3.46	20	17.5	(1805)
$C_{10}H_{22}O_4$	2, 5-Dihydroxy-3, 4-dimethoxy-2, 5-dimethylhexane ($HO.C(CH_3)_2.CH(OCH_3).CH(OCH_3).CH(CH_3)_2.OH$)	MeOH	3.5244	20	−30.9	(1747)
		Me_2CO	5.0884	20	−41.96	
$C_{17}H_{20}N_2O_3$	*d*-Erythrose benzylphenylhydrazone	EtOH	*10.32*	20	−32	(1806)
$C_{28}H_{26}O_4$	Tetraphenylerythritol	EtOH	*4.33*	20	182.8	(659)

HYDROXYAMINES

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{15}NO$	Ephedrine ($C_6H_5.CHOH.CH.(CH_3).NH.CH_3$)	EtOH	3.6	20	−6.3	(701); *cf.* (426.5)
	Pseudoephedrine	EtOH	4.07	20	51.2	
$C_{10}H_{16}ClNO$	Pseudoephedrine hydrochloride	H_2O	14.34	15	−33.8	(262)
$C_{12}H_{18}ClNO_2$	Acetylephedrine hydrochloride	H_2O	4.166	20	96.8	(262)
$C_{14}H_{15}NO$	α, β-Diphenyl-β-hydroxyethylamine‡	C_6H_6?	*3*		±109.7	(432)
$C_{14}H_{16}ClNO$	Hydrochloride	H_2O	*1*		±80.23	(432)
$C_{16}H_{17}NO_2$	Acetyl-*l*-α, β-diphenyl-β-hydroxyethylamine	EtOH	1.26		−12.8	(432)
$C_{17}H_{20}N_2OS$	Ephedrylphenylthiocarbamide	EtOH	3.88	20	−105.1	(701)
	Pseudoephedrylphenylthiocarbamide	EtOH	4.16	20	22.8	
$C_{21}H_{19}NO$	Benzylidene-*d*-α, β-diphenyl-β-hydroxyethylamine	EtOH	1.40		+55	(432)
	Benzylidene-*l*-α, β-diphenyl-β-hydroxyethylamine	EtOH	1.47		−56	(432)
$C_{21}H_{19}NO_2$	Benzoyl-*l*-α, β-diphenyl-β-hydroxyethylamine	MeOH	1		±29.0	(432)

DIAMINES

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{16}N_2$	*d*-*p*-Phenylenedi-α-ethyldiamine ($C_6H_4(CH.(CH_3).NH_2)_2$)	EtOH	4.82	22	18.15	(111)
$C_{17}H_{20}N_2S$	*d*-Diphenyldiethylthiocarbamide ($CS(NH.CH.(CH_3).C_6H_5)_2$)	EtOH	1		22.5	(1284)
	l-Diphenyldiethylthiocarbamide	EtOH			−22.1	
$C_{18}H_{22}N_2S$	Methyl *l*-phenylethylimidophenylethylthiocarbamate ($C_6H_5.CH.(CH_3).N:C-(S.CH_3).NH.CH.(CH_3).C_6H_5$)	EtOH	4.15		96	(1532)
$C_{18}H_{23}ClN_2S$	Hydrochloride	EtOH	3.66		193	(1532)
$C_{18}H_{23}IN_2S$	Hydroiodide	EtOH	12.23		138	(1532)
$C_{18}H_{24}N_2$	*d*-β-γ-Di-*p*-tolylamino-*n*-butane	EtOH	3.35	20	100	(1456)

CARBOXYLIC ACIDS

DIHALOGENO MONO- AND DICARBOXYLIC ACIDS

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_4H_4Br_2O_4$	*l*-α, β-Dibromosuccinic acid	AcOEt	5.788	13	−148	(1329); *cf.* (1328)
		H_2O	2.475	12.5	−62.2	
	l-Isodibromosuccinic acid	AcOEt	8.47		−118	(1328)
$C_6H_8Cl_2O_4$	Dimethyl α, β-dichlorosuccinate	$CHCl_3$	13.1	20	−66	(373)
$C_9H_8Cl_2O_2$	β-Phenyl-α, β-dichloropropionic acid ($C_6H_5.CHCl.CHCl.COOH$)				66.5	(454)
$C_9H_8Br_2O_2$	β-Phenyl-α, β-dibromopropionic acid				−63.6	(454)
$C_{10}H_{10}Cl_2O_2$	Methyl β-phenyl-α, β-dichloropropionate	EtOH			61.9	(454)
$C_{11}H_{12}Cl_2O_2$	Ethyl β-phenyl-α, β-dichloropropionate	EtOH			64.1	(454)

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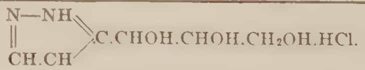
* Mutarotation. † $[\alpha]_{5780}$. ‡ $C_6H_5.CHOH.CH.(NH_2).C_6H_5$. §



$\begin{array}{l} N—NH \\ \| \\ CH.CH \end{array} \rangle C.CHOH.CHOH.CH_2OH.HCl.$

DIHYDROXYDICARBOXYLIC ACIDS

Tartaric acids, its salts and esters

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_4H_6O_6$	Lithium salt (anhyd.)	H_2O	8.31	20	35.84	(1272)
	Thallium salt	H_2O	5	20	4.76	
	Thallium ammonium salt	H_2O	5	20	10.03	(1272)
		H_2O	20	20	7.56	
	Thallium antimony salt (monohydrate)	H_2O	5	20	100.44	(1272)
		H_2O	20	20	99.64	
	Thallium hydrogen salt	H_2O	1	20	12.02	(1272)
	Thallium lithium salt (monohydrate)	H_2O	5	20	9.46	(1272)
		H_2O	20	20	6.69	
	Thallium potassium salt	H_2O	5	20	10.06	(1897); *cf.* (1272)
		H_2O	20	20	8.17	
	Thallium sodium salt (tetrahydrate)	H_2O	5	20	9.07	(1272)
		H_2O	20	20	6.49	
	Potassium arsenyl salt	H_2O	0.56	20	21.13	
	Sodium arsenyl salt	H_2O	3.36	20	20.64	
	Sodium borotartrate	H_2O	2.54	20	55.02	(1272)
		H_2O	10.15		71.5	
	Ammonium titanotartrate	H_2O	2.317	20	−40.1	(750)
		H_2O	0.1448	20	276.3	
$C_4H_4O_8As_2$	Arsenyltartaric acid	H_2O	12.3	20	16.91	(1272)
$C_6H_{14}N_2O_6$	Ethylenediamine tartrate	H_2O	8.4	18	29.2	(349)
		H_2O	2.1	18	29.4	
$C_{10}H_{13}NO_6$	Aniline hydrogen tartrate	H_2O	*2*	17	17.6	(2225)
		H_2O	*5*	17	17.35	
		H_2O	*10*	17	17.54	
$C_{16}H_{20}N_2O_6$	Dianiline tartrate	H_2O	*2*	17	17.72	(2225)
		H_2O	*10*	17	17.67	
$C_5H_8O_6$	Methyl hydrogen *d*-tartrate	H_2O	35	16.5	14.56	(1378)
		H_2O	6.3	18	18.71	
		H_2O	2.07		18.1	(445)
		EtOH	1.04		3.22	
	Ammonium salt	H_2O	2.29		28.0	(445)
	Calcium salt (pentahydrate)	H_2O	22.5	20	17.80	(1378)
	Lithium salt	H_2O	2.15		26.5	(445)
	Potassium salt	H_2O	2.56		22.7	(445)
	Sodium salt	H_2O	2.35		21.0	(445)
$C_5H_8O_6$	Methyl hydrogen mesotartrate	H_2O	9.2	17	−5.43	(1378)
	Ammonium salt	H_2O	6		−20.83	(1378)
	Calcium salt	H_2O	5		−7.3	(1378)
$C_6H_{10}O_6$	Ethyl hydrogen tartrate	H_2O	2.25		21.8	(445)
		EtOH	1.13		7.1	
	Barium salt	H_2O	3.11		20.3	(445)
	Calcium salt	H_2O	2.49		24.3	(445)
	Lithium salt	H_2O	2.33		28.8	(445)
	Potassium salt	H_2O	2.73		21.6	(445)
	Sodium salt	H_2O	2.53		27.5	(445)
$C_{14}H_{22}O_6$	*l*-Bornyl hydrogen *d*-tartrate	EtOH	2.18	14.5	−5.7	(2218)
		EtOH	7.58	12	−6.5	
		Me_2CO	2.38		−1.26	
	l-Bornyl hydrogen *l*-tartrate	EtOH	2.99		−51.7	
$C_{20}H_{38}O_6$	Di-*sec*.-octyl tartrate		1.0195	18	7.06	(1320)
$C_{24}H_{38}O_6$	Di-*l*-bornyl *d*-tartrate	$CHCl_3$	2.03	13.5	−5.17	(2218)
		Me_2CO	2.28	14	−5.71	
		C_6H_6	2.16	12	3.46	
	Di-*l*-bornyl *l*-tartrate	$CHCl_3$	2.52	15	−71.4	
		C_6H_6	2.42	14.5	−77.6	
		Me_2CO	2.54	11.5	−71.3	

Amides of tartaric acid

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_4H_8N_2O_4$	Tartramide	H_2O	*1.31*	20	106.5	(656)
		MeOH	*0.180*	20	144	
$C_6H_{10}N_2O_4$	Tartaric dimethylamide	MeOH	*4.99*	20	148.8	(660)

Amides of tartaric acid.—(*Continued*)

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_6H_{10}N_2O_4$	Tartaric dimethylamide.—(*Cont'd*)	Py	7.68	20	158.3	(656)
		H_2O	0.994	20	144.7	
$C_8H_{16}N_2O_4$	Tartaric diethylamide	Py	5.03	20	136.6	(656)
		H_2O	7.47	20	125.5	
		H_2O	1.39	20	128.6	
		MeOH	5.00	20	137.9	(660)
$C_{10}H_{16}N_2O_4$	Tartaric diallylamide	Py	4.74	20	110.7	(660)
		MeOH	5.9	20	118.4	
		H_2O	4.7	20	107.8	
$C_{10}H_{20}N_2O_4$	Tartaric di-*n*-propylamide	MeOH	4.86	20	124.8	(660)
		H_2O	2.7	20	112.1	
		Py	4.74	20	123.9	
$C_{10}H_{20}N_2O_4$	Tartaric diisopropylamide	Py	4.66	20	117.1	
		MeOH	1.91	20	117.8	
		H_2O	4.68	20	106.3	
$C_{12}H_{12}N_2O_6$	Tartaric difurfurylamide	Py	4.88	20	99.4	(651)
$C_{12}H_{24}N_2O_4$	Tartaric di-*n*-butylamide	Py	4.8	20	110.7	(660)
		MeOH	4.42	20	112.0	
		H_2O	0.258	20	107.5	
$C_{12}H_{24}N_2O_4$	Tartaric diisobutylamide	Py	5.06	20	113.2	
		MeOH	5.43	20	117.2	
		H_2O	0.55	20	105.6	
$C_{14}H_{14}N_4O_6$	Tartaric difurfurylidenehydrazide	Py	3.05	20	219.9	(656)
$C_{14}H_{24}N_2O_4$	Tartaric dipiperidide	Py	3	20	0	(651)
		$PhNH_2$	3	20	0	
$C_{16}H_{14}Br_2N_2O_4$	Tartaric di-*o*-dibromoanilide	Py	6.604	20	142.3	(661)
		MeOH	3.363	20	118.3	
		MeOH	0.9402	20	120.9	
	Tartaric di-*m*-dibromoanilide	Py	4.835	20	189.3	
		MeOH	0.9862	20	154.5	
	Tartaric di-*p*-dibromoanilide	Py	4.908	20	193.2	
		MeOH	0.1359	20	181.1	
$C_{16}H_{14}Cl_2N_2O_4$	Tartaric di-*o*-dichloroanilide	Py	5.060	20	192.1	(661)
		MeOH	1.524	20	164.3	
	Tartaric di-*m*-dichloroanilide	Py	4.966	20	223.4	
		MeOH	1.504	20	182.3	
	Tartaric di-*p*-dichloroanilide	MeOH	1.749	20	196	
		Py	4.81	20	227.2	
$C_{16}H_{16}N_2O_4$	Tartranilide	Py	5.42	20	246.5	(656)
		MeOH	0.08	20	200	
$C_{18}H_{18}N_4O_4$	Tartaric dibenzylidenehydrazide	Py	0.383	20	160.2	(656)
		Py	1.834	20	156.8	
$C_{18}H_{20}N_2O_4$	Tartaric dibenzylamide	Py	5.50	20	91.5	(656)
$C_{18}H_{20}N_2O_4$	Tartaric *o*-toluidide	Py	4.99	20	203	
	Tartaric *m*-toluidide	Py	2.01	20	220	
$C_{18}H_{36}N_2O_4$	Tartaric di-*n*-heptylamide	Py	3.58	20	88.72	(660)
$C_{20}H_{22}N_4O_4$	Tartaric di-α-methylbenzylidene hydroxide	MeOH	0.995	20	88.14	
	$[(CHOH.CO.NH.N{:}C(C_6H_5)CH_3)]_2$	Py	0.747	20	104	(656)
$C_{24}H_{20}N_2O_4$	Tartaric di-α-naphthylamide	Py	6.56	20	100.3	(656)
	Tartaric di-β-naphthylamide	Py	1.32	20	292	
$C_{24}H_{28}N_2O_4$	Tartaric di-*ar*-tetrahydro-β-naphthylamide	Py	4.43	20	205.9	(651)
	Tartaric di-*ac*-tetrahydro-β-naphthylamide	Py	2.17	20	58.4	
	Imides of tartaric acid					
$C_5H_7NO_4$	Tartaric methylimide (partly racemized)	H_2O	19.94		192.6	(1152)
$C_6H_9NO_4$	Tartaric ethylimide	H_2O	8.57		166.2	(1152)
$C_{10}H_9NO_4$	Tartranil	H_2O	0.596	20	114	(656)
		MeOH	1.64	20	130	
		Py	4.76	20	132	
$C_{11}H_{11}NO_4$	Tartaric *p*-toluil	MeOH	1.98	20	118.3	(656)
		Py	6.32	20	165.6	
	Diacetyltartaric acids and derivatives					
$C_8H_{10}O_8$	Diacetyl-*d*-tartaric acid	H_2O	17.95	22	−23.04	(1638)
		H_2O	3.76	22	−19.32	

Diacetyltartaric acids and derivatives.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_8H_{10}O_8$	Diacetyl-*d*-tartaric acid.—(*Cont'd*)	EtOH	7.37	22	−23.63	
		MeOH	4.68	22	−23.74	
$C_8H_8O_7$	Diacetyl-*d*-tartaric anhydride	C_6H_6	2.09		63.05	(1638)
		C_6H_6	1.45		58.69	
		Me_2CO	11.66		59.70	
		Me_2CO	4.40		62.04	
$C_{10}H_{14}O_8$	Dimethyl diacetyl-*d*-tartrate	EtOH	3.57	18	−14.23	(1638)
$C_{10}H_{18}N_2O_8$	Ethylenediamine diacetyl-*d*-tartrate	H_2O		11.5	−12.74	(1638)
	Acid salt	H_2O		11.5	−17.05	
$C_{12}H_{18}O_8$	Diethyl diacetyl-*d*-tartrate	EtOH	23.64	17	1.02	(678)
		EtOH	7.85	14	7.04	
$C_{14}H_{22}O_8$	Di-*n*-propyl diacetyl-*d*-tartrate	EtOH	3.25	15	6.52	(1638)
$C_{16}H_{26}O_8$	Di-*n*-butyl diacetyl-*d*-tartrate		3.25	20	17.8	(678)
		EtOH	13.56	14	10.5	
	Diisobutyl diacetyl-*d*-tartrate	EtOH	7.95	15	10.3	(678, 1638)
$C_{22}H_{24}N_2O_6$	Diacetyltartaric *d*-toluidide	Py	*5.24*	20	19.61	(656)
	Halogenoacetyltartrates					
$C_8H_9Cl_3O_7$	Dimethyl monotrichloroacetyltartrate	$PhNO_2$	*4.75*	48.7	7.10	(1576)
$C_{10}H_8Cl_6O_8$	Dimethyl ditrichloracetyltartrate	$PhNO_2$	*4.9*	20	−3.3	(1576)
		$PhNO_2$	*4.9*	14	−3.41	
		$PhNO_2$	*4.9*	41.5	−2.75	
$C_{12}H_{12}Cl_6O_8$	Diethyl ditrichloracetyltartrate			20	13.49	(1576)
				53	13.23	
				70.7	13.35	
$C_{16}H_{20}Cl_6O_8$	Diisobutyl ditrichloracetyltartrate			20	16.65	(1576)
				157	16.12	
		$PhNO_2$	*5.03*	20	9.49	
		$PhNO_2$	*5.03*	91.9	11.55	
		$PhNO_2$	*4.75*	20	7.83	
	Mono- and dibenzoyltartaric acids and derivatives					
$C_{15}H_{17}NO_9$	Diethyl mono-*m*-nitrobenzoyltartrate	EtOH	*2.38*	20	12.50	
		AcOEt	*4.97*	20	26.52	
		AcOEt	*2.69*	20	29.77	
		$CHCl_3$	*4.04*	20	14.26	
		C_6H_6	*2.999*	20	0	
		Py	*9.00*	20	4.64	
$C_{15}H_{18}O_7$	Diethyl monobenzoyltartrate			24	20.7	(647, 622)
				63	19.02	
				99.5	17.69	
				135	16.36	
$C_{16}H_{19}NO_9$	Diethyl mononitro-*p*-toluyltartrate	EtOH	*2.63*	20	7.02	(644)
		AcOEt	*8.93*	20	19.85	
		$CHCl_3$	*7.66*	20	16.74	
		C_6H_6	*3.88*	20	−10.86	
		Py	*7.05*	20	−20.51	
$C_{16}H_{20}O_7$	Diethyl mono-*o*-toluyltartrate			14	12.08	(647, 662)
				32.5	11.74	
				100	10.88	
				136.5	10.62	
$C_{18}H_{12}O_7$	Dibenzoyltartaric anhydride	Me_2CO	4.644	18	142.94	(1638)
		Me_2CO	1.572	18	143.2	
$C_{18}H_{14}O_8.H_2O$	Dibenzoyltartaric acid	EtOH	8.933	17	−110.91	(1638)
		EtOH	4.994	15	−112.05	
		MeOH	4.857	19	−116.30	
		EtOH	8.506	17	−116.47	
	Anhydrous	EtOH	4.755	15	−117.68	
		MeOH	4.625	19	−122.14	
$C_{20}H_{16}N_2O_{12}$	Dimethyl di-*o*-nitrobenzoyltartrate		1.3484	100	−97.97*	(643)
		C_6H_6	0.856	11	−184.9	
	Dimethyl di-*m*-nitrobenzoyltartrate		1.3760	22	−79.36	(643)
			1.3484	100	−69.22	
			1.3236	179.5	−53.37	

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* Calculated from density of the *m*-compound.

Mono- and dibenzoyltartaric acids and derivatives.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{20}H_{16}N_2O_{12}$	Dimethyl di-*p*-nitrobenzoyltartrate		1.3260	100	−107.56	(643)
			1.2923	136	−92.96	
			1.2531	178	−77.11	
$C_{20}H_{18}O_8$	Dimethyl dibenzoyltartrate			100	−72.56	(647, 622)
		EtOH	0.245	20	−96.61	(1638)
		$CHCl_3$	11.61	19	−88.24	
$C_{22}H_{22}O_8$	Diethyl dibenzoyltartrate	EtOH	9.175	16	−54.50	(1638)
		EtOH	2.69		−60.02	
				18	−59.36	(647, 662)
$C_{22}H_{20}N_2O_{12}$	Diethyl di-*o*-nitrobenzoyltartrate		1.3720	15	−131.85	(643)
			1.2794	100	−62.66	
			1.2412	135	−42.64	
			1.1968	179	−23.71	
	Diethyl di-*m*-nitrobenzoyltartrate		1.3449	20	−70.90	
			1.2679	100	−64.35	
			1.1900	181	−49.08	
	Diethyl di-*p*-nitrobenzoyltartrate		1.3377	13	−129.3	
			1.2648	99	−97.57	
			1.2329	135	−85.47	
			1.1898	181	−67.83	
$C_{26}H_{30}O_8$	Diisobutyl dibenzoyltartrate	EtOH	14.08	22	−48.86	(1638)
		EtOH	2.88	19	−41.95	
$C_{28}H_{34}O_8$	Ethyl octyl dibenzoyltartrate		1.0956	10.8	49.41	(1319)
$C_{34}H_{46}O_8$	Di-*sec*.-octyl dibenzoyltartrate		1.0913	25	−43.94	(1320)
	Nitrotartaric acid and derivatives					
$C_4H_4N_2O_{10}$	Dinitrotartaric acid	MeOH	*0.99*	20	16.48	(645)
		MeOH	*9.09*	20	13.70	
		EtOH	*9.09*	20	13.48	
$C_6H_8N_2O_{10}$	Dimethyl dinitrotartrate	EtOH	2.42	20	27.54	(2099)
		MeOH	*8.38*	20	20.28	(645)
		EtOH	*8.60*	20	13.36	
		C_6H_6	*8.02*	20	19.42	
		C_6H_6	*1.09*	20	23.63	
$C_6H_9NO_8$	Dimethyl mononitrotartrate	MeOH	*4.92*	20	27.43	(645)
		EtOH	*9.09*	20	27.36	
		C_6H_6	*1.77*	20	16.53	
$C_8H_{12}N_2O_{10}$	Diethyl dinitrotartrate	MeOH	2.21		29.87	(2099)
			1.307^{20}_{20}		27.10	
		MeOH	*8.87*	20	27.18	(645)
		EtOH	*8.64*	20	24.27	
		C_6H_6	*9.39*	20	23.76	
$C_8H_{13}NO_8$	Diethyl mononitrotartrate	MeOH	*8.91*	20	35.55	(645)
		EtOH	*8.53*	20	34.44	
		C_6H_6	*8.46*	20	31.31	
$C_{10}H_{16}N_2O_{10}$	Di-*n*-propyl dinitrotartrate		1.2088^{20}_{20}		30.86	(2099)
	Dimethoxysuccinic acid and derivatives					
$C_6H_8Cl_2O_4$	*d*-Dimethoxysuccinyl chloride	Me_2CO	5.3913	20	79.85	(1747)
		$CHCl_3$	1.2484	20	56.87	
		C_6H_6	2.0357	20	104.14	
$C_6H_8O_5$	*d*-Dimethoxysuccinic anhydride	Me_2CO	5.2573	20	148.7	(1747)
		Me_2CO	2.3148	20	148.4	
$C_6H_9NO_4$	*d*-Dimethoxysuccinimide	Me_2CO	*1.6324*	20	235.54	(2224)
		H_2O	*1.6244*	20	178.53	
		EtOH	*1.6168*	20	241.22	
$C_6H_{11}NO_5$	*d*-Dimethoxysuccinamic acid	H_2O	1.3016	20	89.89	(2224)
		H_2O	1.8896	20	88.11	
		EtOH	1.1648	20	103.45	
$C_6H_{12}N_2O_4$	*d*-Dimethoxysuccinamide	H_2O	0.72	20	94.44	(1732)
$C_6H_{14}N_4O_4$	*d*-Dimethoxysuccinic hydrazide	H_2O	1.1516	20	130.25	(2224)
		H_2O	4.3692	20	128.28	
$C_7H_{11}NO_4$	*d*-Dimethoxysuccinic methylimide	Me_2CO	1.2500	20	228.8	(2224)
$C_7H_{12}O_6$	Methyl hydrogen *d*-dimethoxysuccinate	Me_2CO	4.615	20	91.22	(1747)
		H_2O	4.823	20	69.35	
$C_{12}H_{13}NO_4$	*d*-Dimethoxysuccinanil	Me_2CO	1.1228	20	198.16	(1732)
		Me_2CO	2.2824	20	197.16	

Dimethoxysuccinic acid and derivatives.—(Continued)

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_{12}H_{15}NO_5$	*d*-Dimethoxysuccinic monoanilide	Me_2CO	1.2696	20	129.57	(2224)
		EtOH	1.1560	20	128.03	
		Me_2CO	2.2816	20	129.51	
$C_{12}H_{22}O_6$	Propyl *d*-dimethoxysuccinate		1.0612	20	84.92	(1732)
			1.0237	60	81.06	
$C_{18}H_{20}N_2O_4$	*d*-Dimethoxysuccinanilide	Me_2CO	1.198	20	255.43	(2224)
		Me_2CO	1.880	20	254.79	
		EtOH	1.1496	20	227.03	
	Diethoxysuccinic acid and derivatives					
$C_8H_{12}O_5$	*d*-Diethoxysuccinic anhydride	Me_2CO	1.6328	20	143.62	(2224)
		Me_2CO	6.1416	20	143.85	
$C_8H_{14}O_6$	*d*-Diethoxysuccinic acid	Me_2CO	1.3680	20	84.06	(2224)
		Me_2CO	2.2008	20	83.66	
$C_8H_{18}N_4O_4$	*d*-Diethoxysuccinic hydrazide	H_2O	1.2832	20	123.13	(2224)
		H_2O	1.8808	20	124.95	
		H_2O	4.0960	20	125.61	
$C_{10}H_{18}O_6$	Dimethyl *d*-diethoxysuccinate			20	89.28	(2224)
		H_2O	3.962	20	79.00	
$C_{14}H_{17}NO_4$	*d*-Diethoxysuccinanil	Me_2CO	3.8864	20	182.56	(2224)
		EtOH	2.2864	20	180.19	
		C_6H_6	2.1336	20	237.39	
$C_{14}H_{19}NO_5$	*d*-Diethoxysuccinic monoanilide	Me_2CO	2.4488	20	143.54	(2224)
		EtOH	2.4712	20	137.18	
$C_{20}H_{24}N_2O_4$	*d*-Diethoxysuccinic dianilide	Me_2CO	1.180	20	263.14	(2224)
		Me_2CO	1.6984	20	267.60	
		Me_2CO	2.1812	20	278.06	
	Other tartaric acid derivatives with one or both of the hydrogen atoms of the hydroxyl groups substituted					
$C_5H_6O_6$	Monomethylene-*d*-tartaric acid; *cf.* (1262)	H_2O	0.8		−73	(1262.5)
$C_5H_8O_6$	α-Hydroxy-β-methoxysuccinic acid	H_2O	1.85		45.4	(837)
$C_{18}H_{14}O_6$	Dibenzylidene-*d*-tartaric acid*	MeOH			128	(422)
$C_{18}H_{14}O_6$	Di-*p*-tolylidene-*d*-tartaric acid	MeOH			107	
$C_{18}H_{18}O_{10}$	Diethyl dipyromucyltartrate		1.1914	99.5	−67.65	(634)
			1.1524	140	−60.55	
		EtOH	*0.503*	20	−98.54	
		EtOH	*4.94*	20	−86.82	
$C_{20}H_{16}O_7$	Diphenacyltartaric anhydride†				58	(677)
$C_{22}H_{20}O_7$	Diphenylpropionyltartaric anhydride $(C_6H_5.CH_2.CH_2.CO.O.CH.CO)_2O$				38	(677)
	Sulfur derivatives of tartaric acid					
$C_6H_8O_7S$	Dimethyl thionyltartrate		$1.4445^{19.5}_{19.5}$	18	−61	(1871)
$C_7H_{10}O_5S_2$	*d*-Xanthosuccinic acid	EtOH	5.20	17	82.8	
	$(HO.CO.CH(S.CS.OC_2H_5)CH_2.COOH)$	AcOEt	2.69	17	101.7	(917)
	l-Xanthosuccinic acid	AcOEt	5.48	17	−101.6	
$C_8H_{10}O_8S_2$	Dithiosuccinic acid	EtOH	5	17	272.8	(920.2)
		Me_2CO	5	17	270.2	
		H_2O	5	17	290.5	
		H_2O	5.07	17	68.1	
$C_8H_{12}O_7S$	Diethyl thionyltartrate		$1.3257^{19.5}_{19.5}$	18	−56.7	(1871)
			1.329	19.5	−183.8	(1330)
			1.342	9.5	−185.4	
$C_{10}H_{16}O_7S$	Di-*n*-propyl thionyltartrate		1.2382	18	−18.54	(1871)
	Other hydroxycarboxylic acids and derivatives					
$C_4H_8O_4$	*l*-α, β-Dihydroxybutyric acid	H_2O	*5.99*	16	−13.51	(1462)
	Barium salt	H_2O	*6.27*	16	−20.63	(1462)
$C_5H_8O_6$	*d*-α, γ-Dihydroxyglutaric acid	H_2O	0.668		3.9	(1065)
$C_6H_{10}O_6$	*d*-α, α′-Dihydroxyadipic acid	H_2O?	6.16	16	3.8	(1201)
	Ammonium salt	H_2O	6.16	16	−21.4	(1201)
$C_9H_{10}O_4$	*l*-Phenylglyceric acid	H_2O	*3.16*	20	−39.63	(1782)
	$(C_6H_5.CHOH.CHOH.COOH)$	98% EtOH	*6.28*	20	−30.48	
		Me_2CO	*7.36*	20	−36.43	

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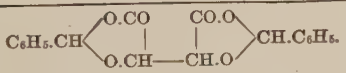
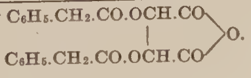
* 
$C_6H_5.CH<(O.CO, O.CH)\text{—}(CO.O, CH.O)>CH.C_6H_5.$

† 
$C_6H_5.CH_2.CO.OCH.CO / C_6H_5.CH_2.CO.OCH.CO > O.$

Other hydroxycarboxylic acids and derivatives.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{14}N_2O_4$	*l*-Threonyl phenylhydrazide ($HO.CH_2.$-$CHOH.CHOH.CO.NH.NH.C_6H_5$)	H_2O	*4.75*	20	−26.88	(1490)
$C_{14}H_{28}O_4$	Ipurolic acid ($C_{13}H_{25}(OH)_2.COOH$)	EtOH	13.0		0	(1705)
$C_{15}H_{30}O_4$	Methyl ipurolate ($C_{13}H_{25}(OH)_2CO.OCH_3$)	EtOH	3.45		1.69	(1705)
$C_{18}H_{36}O_4$	*d*-θ-λ (9,12)-Dihydroxystearic acid (CH_3-$(CH_2)_5.CHOH(CH_2)_2.CHOH(CH_2)_7.$-$COOH$)	EtOH	*4.3*		6.45	(757)

IB_3 to IB_n. CARBOHYDRATES AND RELATED COMPOUNDS*

Sugars Containing 5 Carbon Atoms and Related Compounds

Methyltetroses

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_5H_{10}O_4$	Methyltetrose ($CH_3(CHOH)_3.CHO$)	9.6% EtOH	9.47		−16.35†	(1807)
$C_5H_8O_4$	Methyltetronic lactone	H_2O	5.9	20	−47.5	(1807)
$C_6H_{12}O_5$	α-Glucodesose (2-Desoxyglucose (5 min.)	Py	*4.16*	19	90.11†	(112)
	(5 after min.)	H_2O	*9.21*	19	46.52	
	β-Glucodesose ($H(CHOH)_3.CH_2.CHO$) (after 5 min.)	H_2O	*9.50*	18	46.59†	
	(after 5 min.)	Py	*2.03*	18	15.03	
	(after 24 hr.)				90.21	
$C_{27}H_{23}BrO_7$	Tribenzoylbromoglucodesose	$C_2H_2Cl_4$	*4.49*	16	121.4	(112)
$C_{27}H_{24}O_8$	Tribenzoylglucodesose	$C_2H_2Cl_4$	*5.18*	19	38.39	(112)
$C_{28}H_{26}O_8$	Tribenzoylmethylglucodesoside	$C_2H_2Cl_4$	*8.63*	19	−34.31	(112)
$C_{34}H_{28}O_9$	Tetrabenzoylglucodesose	$C_2H_2Cl_4$	*9.32*	16	8.96	(112)

Arabinose and derivatives

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_5H_{10}O_5$	*d*-Arabinose ⎫ *cf.* (95.5 1061, 1558, 1862.5,	H_2O	*10.11*	20	−104.1†	(2205)
	l-Arabinose ⎭ 2206) ($H(CHOH)_4.CHO$)	H_2O	10	18	104.4	(1258, 1860)
$C_5H_{13}NO_4$	Arabinamine ($H(CHOH)_4.CH_2.NH_2$)	H_2O	5.46	15	−4.58	(1803, 1804)
$C_6H_{12}O_5$	α-Methylarabinoside	H_2O	10.01	20	245.7	(1741)
	β-Methylarabinoside	H_2O	8.16	20	73.24	
$C_6H_{13}N_3O_5$	Arabinose semicarbazone	H_2O	*40*		23.8†	(1375)
$C_7H_{10}Cl_2O_5$	Dechloroarabinochloralose	H_2O		15	−19.72	(826)
$C_8H_{16}O_5$	2, 3, 4-Trimethylarabinose	H_2O	7.98	20	127.2	(1741)
$C_9H_{18}O_5$	2, 3, 4-Trimethyl-α-methylarabinoside	H_2O	*9.9*	20	250.8	(1741)
		MeOH	*12.13*	20	223.1	
$C_{11}H_{15}BrO_7$	Triacetylbromo-*l*-arabinose; *cf.* (287)	$CHCl_3$	1.86	20	287.11	(233)
$C_{11}H_{15}ClO_7$	Triacetylchloro-*l*-arabinose; *cf.* (287)	$CHCl_3$	2.4	20	244.4	(233)
$C_{11}H_{15}FO_7$	Triacetylfluoro-*l*-arabinose	$CHCl_3$	2.4	20	138.18	(233)
$C_{11}H_{15}IO_7$	Triacetyliodo-*l*-arabinose	$CHCl_3$	2.5	20	339.06	(233)
$C_{12}H_{28}N_2O_{12}$	Arabinamine oxalate	H_2O	5	15	−13.5	(1803, 1804)
$C_{17}H_{18}O_4$	Anhydro-1, 1-diphenylarabitol	Me_2CO	*1.37*	8	114.8	(1550)
$C_{17}H_{20}N_2O_4$	*l*-Arabinose diphenylhydrazone	Py	*1.05*		14.9	(1480)
$C_{17}H_{20}N_4O_3$	Arabinososazone (initial rotation); *cf.* (455)	EtOH	3.4	20	18.90†	(25)
$C_{17}H_{20}O_5$	1-1, Diphenyl-*l*-arabitol ($HO.C(C_6H_5)_2.(CHOH)_3.CH_2OH$)	H_2O	*0.4075*	20	85.6	(1550)
$C_{19}H_{18}O_5$	Dibenzylidenearabinose	MeOH	*0.4*		26.8	(421)
$C_{19}H_{24}O_5$	α, α-Dibenzyl-*l*-arabitol	EtOH	*0.2689*	19	31.5	(1550)
$C_{19}H_{24}O_5$	α, α-Di-*p*-tolyl-*l*-arabitol	EtOH	*0.5491*	18	71.62	(1550)
$C_{21}H_{22}O_5$	Di-*p*-toluylidenearabinose	$CHCl_3$	*0.4*		2.9	(421)
$C_{22}H_{22}O_{10}$	β-Homonataloin‡	60% EtOH	1		0	(1189)
	γ-Homonataloin	60% EtOH	1		−146.2	
	δ-Homonataloin	60% EtOH	1		110.6	
$C_{23}H_{24}O_{10}$	Nataloin (natural)	60% EtOH	1		−145	(1189)
	β-Nataloin	60% EtOH	1		10	
	γ-Nataloin	60% EtOH	1		−143.7	
	δ-Nataloin	60% EtOH	1		−146	
$C_{32}H_{32}O_{15}$	γ-Pentaacetylhomonataloin	EtOH			−54.2	
$C_{33}H_{34}O_{15}$	γ-Pentaacetylnataloin	EtOH			−53	(1189)
		AcOH			−58	
	δ-Pentaacetylnataloin	EtOH			−56.1	

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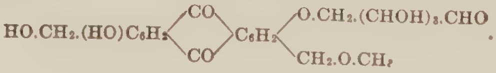
* *See also* Vol. II, p. 334. † Mutarotation.

‡ 

$$HO.CH_2.(HO)C_6H_2\left\langle\begin{matrix}CO\\CO\end{matrix}\right\rangle C_6H_2\left\langle\begin{matrix}O.CH_2.(CHOH)_3.CHO\\CH_2.O.CH_2\end{matrix}\right.$$

Xylose and derivatives

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_5H_{10}O_5$	*d*-Xylose (equilibrium)	H_2O	*9.937*	20	−18.6*	(542)
	l-Xylose (after 24 hours)	H_2O	*3.115*	20	18.42*	(1911)
		H_2O	*5.376*	20	18.55*	
		H_2O	*9.706*	20	18.77*	
		H_2O	*21.744*	20	19.61*	
		H_2O	*34.355*	20	20.49*	
		H_2O	*46.395*	20	21.43*	
		H_2O	*56.229*	20	22.68*	
		H_2O	*61.747*	20	23.70*	
		H_2O	10.664	20	19.22*	(1558); *cf.* (2173)
$C_5H_{10}O_5$	α-*l*-Xylose (initial)	H_2O			9.2†	(1991)
	(equilibrium)	H_2O			18.5†	(1991)
$C_5H_{11}NO_4$	Xylosimine (after 63 hr.) (H(CHOH)$_4$.CH: NH)	H_2O	*4.778*		−15.9*	(1220)
	(after 24 hr.)	H_2O	*4.804*		−15.71*	
$C_5H_{13}NO_4$	Xylosamine (H(CHOH)$_4$.CH$_2$.NH$_2$)	H_2O	5.28	15	−8.52	(1803, 1804)
$C_5H_{14}INO_4$	Xylosamine hydroiodide	H_2O	8	15	−12.50	(1803, 1804)
$C_6H_{12}O_5$	Monomethyl-*l*-xylose (equilibrium)	H_2O			42†	(1991)
$C_6H_{13}N_3O_5$	Xylose semicarbazone	H_2O	*40*		24.4*	(1375)
$C_7H_{14}O_5$	Dimethyl-*l*-xylose (equilibrium)	H_2O			24†	(1991)
$C_8H_{14}O_5$	Isopropylidene-*l*-xylose	H_2O			−19†	(1991)
$C_9H_{16}O_5$	1, 2-*sec.*-Butylidene xylose ether	H_2O	*6.04*		−8.0†	(1993)
	Monomethylisopropylidenexylose	H_2O	0.568	18	−21.4†	(1991)
$C_{10}H_{18}O_5$	Dimethylisopropylidenexylose	H_2O	2.34	18	−43.3†	(1991)
$C_{11}H_{15}BrO_7$	Triacetylbromoxylose	$CHCl_3$	2.54	20	212.2	(365)
$C_{11}H_{15}FO_7$	Triacetylfluoroxylose	$CHCl_3$	3.0	20	67.24	(231)
$C_{11}H_{16}O_8$	Triacetyl-β-xylose	$CHCl_3$		20	−24.9	(365)
$C_{12}H_{18}O_8$	Triacetyl-β-methylxyloside	$CHCl_3$	2.70	20	−60.8	(365)
$C_{12}H_{20}O_5$	1, 2-*sec.*-Butylidene-4, 5(?)-isopropylidene-xylose	H_2O	1.22		15.7	(1993)
$C_{12}H_{20}O_5$	1, 2-Isopropylidene-4, 5(?)-*sec.*-butylidene-xylose	H_2O	0.79		16.1†	(1993)
$C_{13}H_{22}O_5$	1, 2, 4, 5(?)-Di-*sec.*-butylidenexylose	H_2O	0.51		17.4*	(1993)
$C_{17}H_{20}N_4O_3$	Xylosazone	EtOH	*2.815*		−43.36	(455)
$C_{19}H_{18}O_5$	Dibenzylidenexylose	MeOH	*0.4*		37.5	(421)
$C_{21}H_{22}O_5$	Di-*p*-toluylidenexylose	Me_2CO			45.6	(421)

Other pentoses

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_5H_{10}O_5$	Cyclose	H_2O		20	48.78	(1656)
$C_{25}H_{42}O_{12}$	Cyclamin	H_2O?	*2*	20	−36.3	(1656)
$C_5H_{10}O_5$	*l*-Ribose	H_2O	*1.5*		18.8*	(425)
$C_{17}H_{18}Br_2N_4O_3$	*d*-Ribose *p*-bromophenylosazone	EtOH	*0.998*		−16	(1230)
$C_{11}H_{16}N_2O_4$	Carnose phenylhydrazone	EtOH	3.77	20	4.53	(1229)
$C_{11}H_{15}BrN_2O_4$	Carnose *p*-bromophenylhydrazone	EtOH	4.05	20	−5.69	(1229)
$C_{18}H_{22}N_2O_4$	*d*-Lyxose benzylphenylhydrazone	EtOH	*4.89*		26.39	(1808)

Acids derived from pentoses

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_5H_8O_5$	Arabonic lactone	H_2O	9.45	20	−73.9	(533)
	Strontium salt of arabonic acid (*C* at 100°C)	H_2O	4.353	20	1.96	(26)
$C_5H_8O_5$	Ribonic lactone	H_2O	9.34	20	−18.0	(533)
	Cadmium salt of ribonic acid	H_2O		20	0.6	(533)
$C_5H_8O_5$	Lyxonic acid lactone	H_2O	*9.78*	20	82.4	(494)
$C_5H_8O_7$	*l*-Trioxyglutaric acid	H_2O	9.59	20	−22.7	(2184)
	Potassium salt	H_2O	10.863	16	9.35	(2184)
$(C_5H_9O_6)_2Sr.6H_2O$	Strontium xylonate (*C* at 100°C)	H_2O	4.305	20	12.14	(26)
$C_7H_{10}O_6$	Dimethylenexylonic acid	H_2O	7.5		39.2	(334)
$C_{11}H_{14}O_8$	Triacetyl-*l*-arabonic lactone‡	C_6H_6	*1.8584*	18.5	−60.5	(1550)
$C_{17}H_{16}O_6$	1, 1-Diphenyl-2, 3, 4-trihydroxytetrahydrofurfurane-4-carboxylic acid§	EtOH	*1.1869*	14	119.5	(1550)
		EtOH	*1.345*	17	201.7	

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* Mutarotation. † $[\alpha]_{7580}$. ‡ $CH_3.CO.O.CH_2.\underbrace{CH.CH(O.CO.CH_3).CH(O.CO.CH_3)CO}_{O}$. § $\underbrace{C(C_6H_5)_2.CHOH.CHOH.COH}_{O}.COOH$.

PENTAHYDRIC AND HEXAHYDRIC ALCOHOLS CONTAINING 6 CARBON ATOMS

Mannitol and derivatives

Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_6H_8Cl_4O_4S$	Mannitoltetrachlorohydrine sulfate	$C_2H_2Cl_4$	*5.12*	15	105.1	(848)
$C_8H_{18}O_6$	5, 6-Dimethylmannitol	H_2O	2.47	20	−7.35	(979, 980)
		EtOH	2.47	20	−8.85	
$C_{10}H_{22}O_6$	1, 2, 3, 4-Tetramethylmannitol	H_2O	2.49	20	22.1	(979, 980)
		EtOH	1.74	20	39.8	
	3, 4, 5, 6-Tetramethylmannitol	H_2O	1.92	20	−13.02	
		EtOH	1.81	20	−12.54	
$C_9H_{18}O_6$	Isopropylidenemannitol	H_2O	2.76	20	26.4	(979, 980); *cf.* (465.5)
		EtOH	2.63	20	23.2	
$C_{12}H_{22}O_6$	Diisopropylidenemannitol	H_2O	2.69	20	19.31	(979, 980); *cf.* (465.5)
		EtOH	2.70	20	15.75	
$C_{14}H_{26}O_6$	Dimethyldiisopropylidenemannitol	H_2O	2.57	20	25.7	(979, 980)
		EtOH	2.08	20	21.9	
$C_{34}H_{30}O_{10}$	Tetrabenzoylmannitol	$C_2H_2Cl_4$	*7.46*	18	7.83	(487)
$C_{37}H_{34}O_{10}$	Tetrabenzoylisopropylidenemannitol	$C_2H_2Cl_4$	*9.7*	20	0.60	(487)
		PhMe	*10.15*	20	15.43	
$C_{48}H_{38}O_{12}$	Hexabenzoylmannitol	$CHCl_3$	2.119		50.7	(1701)
$C_{60}H_{50}O_{12}$	Hexacinnamylmannitol	$CHCl_3$	*8.16*	21	12.96	(528)
		$CHCl_3$	*7.57*	20	13.15	
	Dulcitol					
$C_{18}H_{20}O_5$	Anhydro-α, α-diphenyldulcitol					
	Hydrated	H_2O	*0.98*	20	−108.6	(1547)
	Anhydrous	H_2O	*2.14*	20	−82.1	
$C_{18}H_{22}O_6$	1, 1-Diphenyldulcitol ($HO.C(C_6H_5)_2.(CHOH)_4.CH_2OH$)	H_2O	*0.3*	20	72.9	(1547)
		EtOH	*0.3*	20	56.2	
		AcOEt	0.35	20	76.4	
$C_{20}H_{26}O_6$	1, 1-Dibenzyldulcitol	EtOH	*0.26*	20	1.46	
$C_{28}H_{32}O_{11}$	1, 1-Diphenyl-2, 3, 4, 5, 6-pentaacetyldulcitol	EtOH	*0.69*	20	14.6	(1547)
$C_{32}H_{30}O_8$	1, 1-Diphenyldibenzoyldulcitol	EtOH	*0.467*	18	64.7	(1547)
	Sorbitol, sorbieritol and other isomerides of mannitol					
$C_6H_{14}O_5$	2-Desoxysorbitol ($H(CHOH)_3.CH_2.CH_2.OH$)	H_2O	*9.11*	18	15.61	(112)
$C_6H_{14}O_6$	Sorbieritol (*d*-iditol)	H_2O	*10*	20	−3.53	(127)
$C_6H_{14}O_6$	*l*-Iditol	H_2O	*10*	20	−3.5	(133)
$C_6H_{14}O_6$	*d*-Talitol	H_2O	*10*	18	3.05	(131)
$C_{10}H_{22}O_6$	Tetramethylsorbitol	H_2O	1.463		−6.2	(962)
$C_{12}H_{22}O_5$	Diisopropylidene-β-desoxysorbitol	$C_2H_2Cl_4$	*1.20*	20	11.08	(112)
$C_{14}H_{20}O_9$	Styracitol tetraacetate	EtOH	*10.3*	22	−20.86	(53)
$C_{18}H_{22}O_6$	1, 1-Diphenylhexane-1, 2, 3, 4, 5, 6-hexol ($HO.C(C_6H_5)_2.(CHOH)_5.H$)	EtOH	0.77		77.9	(1548)
$C_{18}H_{26}O_{12}$	Hexaacetylsorbieritol	$CHCl_3$	*5*	18	26.66	(127)
$C_{18}H_{22}O_6$	1, 1-Diphenyl-*d*-sorbitol	H_2O	*1.23*	25	71.25	(1549)
		EtOH	*1.47*	25	74.75	
$C_{18}H_{22}O_6$	1, 1-Diphenyl-*d*-galactohexitol ($HO.C(C_6H_5)_2.(CHOH)_4.CH_2OH$	H_2O	*1.20*	20	72.9	(1551)
		EtOH	*2.13*	20	56.23	
$C_{18}H_{26}O_{12}$	Hexaacetyl-*l*-iditol	$CHCl_3$	*5*	20	25.33	(133)
$C_{20}H_{26}O_6$	1, 1-*p*-Ditolylsorbitol	EtOH	*0.4*	20	97.1	(1547)
	SUGARS CONTAINING 6 CARBON ATOMS					
	Methylpentoses: Rhamnose and derivatives					
$C_6H_{12}O_5$	Rhamnose; *cf.* (110, 715.5, 993, 1248, 1769, 1912, 1988, 2001, 2180)	H_2O	10	19.5	8.56	(1881)
$C_7H_{15}N_3O_5$	Rhamnose semicarbazone (after 120 hr.)	H_2O	*40*		50*	(1375)
$C_{10}H_{20}O_5$	Trimethylmethylrhamnoside		1.0724	20	−62.18	(1746)
		H_2O	*10.66*	20	−15.54	
		EtOH	*13.65*	20	−53.13	
$C_{11}H_{20}O_5$	Dimethylisopropylidenerhamnoside		1.0795	20	−33.40	(1746)
		MeOH	*11.02*	20	−31.10	
		Me_2CO	*12.48*	20	−35.32	
$C_{12}H_{17}NO_4$	Rhamnoseanilide	EtOH		20	77.1	(975)
$C_{12}H_{18}N_2O_4$	Rhamnose phenylhydrazone	H_2O	*1.011*	20	54.3	(553); *cf.* (993)

* Mutarotation.

Methylpentoses: Rhamnose and derivatives.—(Continued)

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_{13}H_{17}NO_6$	Rhamnose-*o*-carboxyanilide	MeOH	very dil.	20	51.2	(968)
$C_{13}H_{18}N_4O_6$	Theophyllinerhamnoside	H_2O	*9.105*	22	−77.97	(501)
$C_{19}H_{24}N_4O_9$	Theophyllinetriacetylrhamnoside*	$C_2H_2Cl_4$	*5.85*	20	−48.87	(501)
$C_{20}H_{22}O_5$	Dibenzylidenerhamnose	MeOH			56.3	(421)
$C_{21}H_{20}O_{11}$	Quercitrin	Py	1.112		−140.9	(1453)
	Fucose and other methylpentoses					
$C_6H_{12}O_5$	Fucose	H_2O	6.915	20	−77.0†	(761)
		H_2O	7.06		−75.6†	(2036)
$C_6H_{12}O_5$	Rhodeose	H_2O	4.02		74.5	(2081)
	Isorhodeose	H_2O	1.44		20.3	(2082)
$C_6H_{12}O_5$	Styracitol	H_2O		20	−71.72	(52)
$C_6H_{14}O_5$	Fucitol (methylpentitol)	10% Borax	*2.7*	20	4.7	(2083)
$C_{13}H_{20}N_2O_4$	Fucose methylphenylhydrazone	Py	1.85		3.1	(1479)
$C_{14}H_{20}O_9$	Tetraacetylmethylpentose	$CHCl_3$	3.619		21.64	(1705)
$C_{19}H_{24}N_2O_4$	Fucose benzylphenylhydrazone	Py	1.85		9.1	(1479)
	Ketoses: Fructose and derivatives					
$C_6H_{12}O_6$	*d*-Fructose (levulose) ($H(CHOH)_4.CO.CH_2OH$)	H_2O	6.93	20	−90.9	(941)
		H_2O	*50*	15	96.19	(1598)
$C_7H_{14}O_6$	β-Methyl-*d*-fructoside	H_2O	10.02	20	−172.1	(941)
$C_7H_{14}O_6$	Monomethyl-*d*-fructose	H_2O	*1*	20	−53.1†	(967)
		MeOH	*1*	20	22.1†	
$C_9H_{16}O_6$	α-Isopropylidene-*d*-fructose; *cf.* (465.5)	H_2O		20	−159	(963)
$C_{12}H_{20}O_6$	α-Diisopropylidene-*d*-fructose; *cf.* (465.5)	H_2O		20	−161	(963)
$C_{14}H_{19}BrO_9$	Tetraacetylbromo-*d*-fructose	$CHCl_3$	1.908	20	−186	(232)
		$CHCl_3$	3.276	20	−189.1	
$C_{14}H_{19}FO_9$	Tetraacetylfluoro-*d*-fructose	$CHCl_3$	5.92	20	−90.43	(232)
$C_{15}H_{22}O_{10}$	Tetraacetyl-β-methyl-*d*-fructoside	$CHCl_3$	8	20	−124.6	(941)
$C_{16}H_{22}O_{11}$	Pentaacetyl-α-*d*-fructose	$CHCl_3$	8	20	34.75	(940)
		C_6H_6	2.00	20	−105.5	(939, 940)
	Pentaacetyl-β-*d*-fructose	$CHCl_3$	5.00	20	−120.9	(939, 940)
	Sorbose and other ketoses					
$C_6H_{12}O_6$	*d*-Sorbose ($H(CHOH)_4.CO.CH_2OH$)	H_2O	*1*		+42.9	(423); *cf.* (1597.5)
	l-Sorbose	H_2O	9.957		−43.4	
		H_2O	*1*		−42.9	
	Glucose: Alkyl and alkylidene derivatives					
$C_6H_{10}O_4$	Isoglucal (isomer of $HO.CH_2.\overbrace{CH(CHOH)_2CH}^{O}:CH)$)	H_2O	*9.37*	23	43.15	(111.5)
$C_6H_{10}O_5$	Anhydroglucose	H_2O	*9.35*	20	53.9	(559)
$C_6H_{12}O_5$	Glucodesoses, *see* Methyltetroses, p. 386					
$C_7H_{12}O_6$	Methyleneglucose	H_2O?	1.13		9.3	(2035)
$C_7H_{14}O_6$	α-6-Monomethylglucose	MeOH	1	20	68.5†	(966, 984)
	β-6-Monomethylglucose	MeOH	1	20	68.3†	
	Methylglucose	H_2O	1	20	57†	(1236)
$C_8H_{12}Cl_2O_6$	α-Dechlorochloralose	H_2O		15	9.96	(826)
$C_8H_{16}O_6$	2, 3-Dimethyl-α-glucose	AcOH	1.0	20	48.3†	(984)
	2, 3-Dimethyl-β-glucose	H_2O	5.00	20	64.4†	
		EtOH	5.02	20	49.4†	
		AcOH	3.84	20	50.9†	
$C_9H_{16}O_6$	α-Isopropylideneglucose	H_2O		20	−11	(963); *cf.* (465.5)
$C_9H_{18}O_6$	2, 3, 6-Trimethylglucose	40% HCl	1.52		92	(912); *cf.* (839)
		MeOH	0.933		67.5	
	2, 3, 5-Trimethylglucose	40% HCl	1.20		91	
	3, 5, 6-Trimethylglucose	H_2O	4.39	20	−8.32†	(984)
		EtOH	4.67	20	−8.34†	
$C_{10}H_{10}Cl_6O_6$	Dichloralglucose (from cellulose)	$CHCl_3$	5		−12	(1800)
$C_{10}H_{20}O_6$	Tetramethyl-γ-glucose	H_2O	2.080	20	−7.21†	(962)
		MeOH	1.827	20	−19.7	
		C_6H_6	1.641	20	−17.1	

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* $C_7H_7O_2N_4.C_6H_8O(OCOCH_3)_3$. † Mutarotation.

Glucose: Alkyl and alkylidene derivatives.—(*Continued*)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{20}O_6$	Tetramethylglucose	EtOH	5.01	20	78.2	(1733); *cf.* (837, 912)
		H_2O	5.02	20	80.8	
$C_{10}H_{22}O_5S_2$	Glucoseethylmercaptol $(H(CHOH)_4.CH(S.C_2H_5)_2$	H_2O	*4.878*	50	−29.8	(464)
$C_{12}H_{20}O_6$	*α*-Diisopropylideneglucose	H_2O		20	−18	(963); *cf.* (465.5)
$C_{13}H_{22}O_6$	Diisopropylidene-3-methylglucose	EtOH			−32.2	(983)
$C_{19}H_{22}N_2O_3$	Isoglucal phenylbenzylhydrazone	MeOH	*2.45*	22	−21.89	(11.5)
	Acyl derivatives of glucose					
$C_{12}H_{17}BrO_8$	Triacetylglucose bromohydrin	Me_2CO	*8.738*	20	23.33	(559)
$C_{14}H_{19}BrO_9$	Bromotetraacetylglucose	$CHCl_3$	11.6	19	198.17	(1118)
$C_{14}H_{19}FO_9$	Fluorotetraacetylglucose	$CHCl_3$	*3.05*	20	90.08	(231)
$C_{14}H_{19}NO_{12}$	Tetraacetylnitroglucose	$CHCl_3$	*5.21*	18	149.30	(1118)
$C_{15}H_{19}NO_{10}$	Tetraacetylcyanoglucose	$C_2H_2Cl_4$	*5.318*	16	15.86	(485)
	Tetraacetylisocyanoglucose	$C_2H_2Cl_4$	*5.878*	19	−7.54	
$C_{16}H_{22}O_{11}$	*α*-Glucose pentaacetate	C_6H_6	7.7	20	96.7	(942)
		$CHCl_3$	8.1	20	101.6	
		99.5% Me_2CO	8.3	20	108.7	
		50% Me_2CO	3.9	20	108.1	
		EtOH (abs.)	0.52	20	100.9	
		MeOH	1.5	20	104.6	
$C_{16}H_{22}O_{11}$	*β*-Glucose pentaacetate	C_6H_6	7.7	20	2.7	(942)
		$CHCl_3$	8.3	20	3.8	
		99.5% Me_2CO	8.5	20	4.1	
		50% Me_2CO	3.6	20	3.2	
		EtOH (abs.)	0.54	20	1.9	
		MeOH	1.2	20	4.9	
$C_{16}H_{22}O_{16}$	*β*-Pentacarbomethoxyglucose	$CHCl_3$	*5.10*	20	1.35	(2241)
$C_{21}H_{24}O_{11}$	*β*-Tetraacetylbenzoylglucose	$CHCl_3$	*2.10*	20	−28.1	(2241)
$C_{21}H_{24}O_{12}$	*β*-Tetraacetylsalicylglucose	$CHCl_3$	*2.17*	20	−43.4	(2241)
$C_{21}H_{32}O_{16}$	*β*-Pentacarboethoxyglucose	$CHCl_3$	*5.30*	20	2.47	(2241)
$C_{23}H_{27}NO_{12}$	*β*-Tetraacetylhippurylglucose	$CHCl_3$	*2.25*	20	3.64	(2241)
$C_{31}H_{52}O_{11}$	*β*-Pentaisovalerylglucose	$CHCl_3$	*3.56*	20	9.1	(2241)
$C_{34}H_{27}BrO_9$	*β*-Bromotetrabenzoyl-*d*-glucose	PhMe	*10.88*	20	145.1	(508.5)
$C_{41}H_{32}O_{11}$	Pentabenzoylglucose	$CHCl_3$	*8.387*	19	25.37	(508.5)
$C_{41}H_{32}O_{16}$	Penta-*p*-hydroxybenzoylglucose	EtOH	*5.157*	20	124.3	(503)
		EtOH	*4.989*	12	128.8	
$C_{41}H_{32}O_{26}$	Pentagalloylglucose	H_2O	*1.0*	20	31.4	(503)
		H_2O	*1.0*	20	35.7	
		EtOH	*2.250*	20	44.4	
$C_{51}H_{42}O_{11}$	*α*-Pentacinnamylglucose	$CHCl_3$	*2.76*	20	198.8	(528)
	β-Pentacinnamylglucose	$CHCl_3$	*4.37*	20	−3.6	
$C_{51}H_{42}O_{21}$	Penta-3, 4-dihydroxycinnamylglucose	EtOH	*1.01*	20	57.4	(528)
$C_{51}H_{42}O_{26}$	Penta-(-*p*-carbomethoxyhydroxybenzoyl)-glucose	$C_2H_2Cl_4$	*2.1*	20	100.00	(503)
$C_{58}H_{51}BrO_{33}$	*l*-Bromotetra-(triacetylgalloyl)-glucose	Me_2CO	*1.11*	16	58.83	(1039)
$C_{60}H_{54}O_{35}$	Acetyltetra-(triacetylgalloyl)-glucose	Me_2CO	*0.555*	20	44.9	(1041)
$C_{66}H_{122}O_{11}$	*α*-Pentalaurylglucose	$CHCl_3$	*2.15*	20	40.62	(2241)
	β-Pentalaurylglucose	$CHCl_3$	*6.16*	20	3.9	
$C_{71}H_{62}O_{41}$	Penta-(3, 4-dicarbomethoxydihydroxycinnamyl)-glucose	$CHCl_3$	*1.02*	20	114.0	(528)
$C_{71}H_{62}O_{56}$	Penta-(tricarbomethoxygalloyl)-glucose	$C_2H_2Cl_4$	*3.27*	20	34.34	(551)
	Methylglucosides					
$C_7H_{12}O_5$	Anhydromethylglucoside	H_2O	*8.25*	23	−136.6	(559)
$C_7H_{14}O_6$	*α*-Methylglucoside	H_2O	1.56	16	157.9	(66); *cf.* (465.5)
$C_7H_{14}O_6$	*β*-Methylglucoside	H_2O	1.689	18	−32.06	(109, 195)
$C_9H_{18}O_6$	2, 3-Dimethyl-*α*-methylglucoside	H_2O	5.08	20	142.6	(984)
		EtOH	5.07	20	143.1	
		AcOH	4.25	20	143.5	
$C_{10}H_{18}O_6$	5, 6-Isopropylidenemethylglucoside	MeOH	4.45	20	−11.7	(1323)
		EtOH	4.11	20	−11.4	
$C_{10}H_{20}O_6$	Trimethyl-*α*-methylglucoside	MeOH	2.82		160.3	(837)
			1.1656	30	129.8	(1733)

Methylglucosides.—(Continued)

Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{11}H_{22}O_6$	Tetramethyl-α-methylglucoside		1.1006	20	140.6	(1733)
	Different sample		1.1025	20	128.1	
		EtOH	5.01	20	140.5	
	Different sample	EtOH	5.42	20	127.8	
		EtOH	*12.34*	20	31.17	(1734)
		H_2O	*10.0*	20	29.94	
			1.1082	20	171.0	
$C_{11}H_{22}O_6$	Tetramethyl-γ-methylglucoside	H_2O	2.4995	20	−14.6	(962)
		EtOH	2.4985	20	−3.0	
		Me_2CO	2.6215	20	−5.5	
		C_6H_6	2.6665	20	−4.3	
$C_{12}H_{22}O_6$	2, 3-Dimethylmethyl-5, 6-isopropylidene-glucoside	MeOH	6.11	20	−19.0	(1323)
		80% EtOH	10.00	20	−15.0	
$C_{12}H_{22}O_7$	2, 3, 6, Trimethyl-5-acetyl-β-methylglucoside	H_2O	1.235	26	−14.17	(1875)
$C_{14}H_{18}O_6$	Benzylidene-α-methylglucoside	H_2O	*0.4*		85	(421)
	Benzylidene-β-methylglucoside	MeOH	*1*		−75	
$C_{14}H_{19}O_7$	Salicylidene-α-methylglucoside	H_2O	*0.4*		91.2	(421)
$C_{15}H_{20}O_6$	*p*-Toluylidene-α-methylglucoside	MeOH			83.2	(421)
$C_{15}H_{22}O_{10}$	Tetraacetyl-α-methylglucoside	$CHCl_3$	6.3	20	130.55	(942)
		99.5% Me_2CO	2.7	20	134.0	
		50% Me_2CO	3.0	20	126.5	
		MeOH	2.14	20	135.6	
		EtOH	1.17	20	136.8	
		C_6H_6	4.82	20	175.5	
		C_6H_6	*5.39*	15	175.58	(1118)
$C_{15}H_{22}O_{10}$	Tetraacetyl-β-methylglucoside	$CHCl_3$	38.80	20	−18.25	(942)
		99.5% Me_2CO	6.5	20	−19.5	
		50% Me_2CO	38.80	20	−22.45	
		MeOH	2.29	20	−21.8	
		EtOH	1.48	20	−24.6	
		C_6H_6	4.69	20	−22.8	
		C_6H_6	*11.6*	15	−23.1	(1118)
$C_{16}H_{22}O_6$	*l*-5, 6-Benzylidene-2, 3-dimethyl-α-methyl-glucoside	AcOH	1.640	20	97.0	(984)
$C_{17}H_{24}O_7$	2, 3, Trimethyl-5-benzoyl-β-methylglucoside	50% EtOH	0.565	18	−23.87	(1875)
$C_{19}H_{30}O_6$	Tetraallyl-α-methylglucoside	EtOH		30	116.5	(2038)
$C_{35}H_{30}O_{10}$	Tetrabenzoyl-β-methyl-α-glucoside	$CHCl_3$	*7.185*	19	30.99	(508.5)
$C_{35}H_{20}O_{22}$	Tetragalloyl-α-methylglucoside	H_2O	*4.08*	20	26.39	(503)
$C_{59}H_{54}O_{34}$	Tetra-(triacetylgalloyl)-β-methylglucoside	Me_2CO	*1.01*	19	32.9	(1039)
	Tetra-(triacetylgalloyl)-α-methylglucoside	Me_2CO	*1.294*	18.5	42.36	
	Other aliphatic glucosides (including glucosides of geraniol and cholesterol)					
$C_8H_{16}O_6$	α-Ethylglucoside	H_2O	0.98	21	150.9	(66); *cf.* (465.5)
	β-Ethylglucoside	H_2O	*3.98*	20	−30.11	(1118); *cf.* (195.5)
		H_2O	2		−33.38	(190, 195.5)
$C_{16}H_{24}O_{10}$	Tetraacetyl-β-ethylglucoside	C_6H_6	*10.2*	16.5	−27.01	(1118)
$C_8H_{16}O_7$	Glycol-α-monoglucoside ($C_6H_{11}O_5.OCH_2.CH_2OH$)	H_2O	3.00	18	135.5	(205)
	Glycol-β-monoglucoside	H_2O	4.42	18	−30.5	
$C_8H_{14}O_8$	β-*d*-Glucosidoglycolic acid ($C_6H_{11}O_5.OCH_2.COOH$)	H_2O	*8.984*	21	−44.11	(508.5)
		H_2O	*9.054*	21	−43.79	
$C_8H_{15}NO_7$	β-*d*-Glucosidoglycolic amide ($C_6H_{11}O_5.OCH_2.CONH_2$)	H_2O	*10.007*	18	−42.8	(508.5)
		H_2O	*9.888*	18	−43.24	
$C_{18}H_{26}O_{12}$	Ethyl tetraacetyl-β-*d*-glucosidoglycolate ($C_6H_7O(O.COCH_3)_4.OCH_2.CO.OC_2H_5$)	EtOH	*2.351*	35	−39.94	(508.5)
$C_9H_{16}O_6$	Allyl-α-glucoside	H_2O	1.18		131.7	(217, 219)
	Allyl-β-glucoside	H_2O	2.4786		−40.34	(191)
$C_9H_{18}O_6$	*n*-Propyl-α-glucoside	H_2O	1.14		140.8	(219)
		H_2O	1.136		140.8	(217, 219)
	n-Propyl-β-glucoside	H_2O	2.0680		−38.68	(195)

Other aliphatic glucosides (including glucosides of geraniol and cholesterol).—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_9H_{18}O_6$	Isopropyl-β-glucoside	H_2O	2.0666		−36.3	(195)
$C_{10}H_{20}O_6$	Butyl-β-glucoside	H_2O	2.117		−35.4	(191, 196)
	Isobutyl-β-glucoside	H_2O	2.6693		−34.96	
		H_2O	2.17		−39.18	(197.5)
$C_{11}H_{22}O_6$	Amyl-β-glucoside	H_2O	*7.41*	20	−17.2	(539)
$C_{11}H_{22}O_6$	Isoamyl-β-glucoside	H_2O	2.1973		−36.40	(193, 197, 539)
$C_{16}H_{28}O_6$	Geranyl-β-*d*-glucoside ($C_6H_{11}O_5.OCH_2.CH:C(CH)_3.(CH_2)_2.CH:C(CH_3)_2$)	H_2O	*7.603*	27	−37.25	(508.5)
		H_2O	1.6		−25.49	(200, 201, 204)
$C_{22}H_{44}O_6$	β-Cetyl-*d*-glucoside	EtOH	*3.805*	24	−22.02	(508.5)
$C_{24}H_{36}O_{10}$	Tetraacetylgeranyl-β-*d*-glucoside	EtOH	*2.378*	22	−25.17	(508.5)
$C_{30}H_{52}O_{10}$	Tetraacetyl-β-cetyl-*d*-glucoside	EtOH	*1.852*	20	−19.69	(508.5)
$C_{41}H_{64}O_{10}$	Tetraacetylcholesteryl-*d*-glucoside	$CHCl_3$	0.911		−23.8	(1857)
	Tetraacetylsitosteryl-*d*-glucoside	$CHCl_3$	2.847		−22.9	(1857)
$C_{61}H_{72}O_{10}$	Tetrabenzoylsitosteryl-*d*-glucoside	$CHCl_3$	2.366		18.3	(1857)
	Aromatic and hydroaromatic glucosides (with some glucosides of unknown structure)					
$C_{12}H_{13}Br_3O_6$	Tribromo-2, 4, 6-phenyl-*d*-glucoside	Py	*8.395*	26	−23.29	(550)
$C_{12}H_{16}O_5S$	Phenylthiolglucoside ($C_6H_{11}O_5.S.C_6H_5$)	H_2O	*9.95*	20	−72.5	(498)
$C_{12}H_{16}O_6$	Phenyl-α-glucoside	H_2O	*1.91*	20	180.8	(525)
	Phenyl-β-glucoside	H_2O	*2.68*	20	−71.9	(525)
		H_2O	*3.91*	20	−71.0	(488)
$C_{12}H_{16}O_7$	Arbutin (quinol-*d*-glucoside, $C_6H_{11}O_5.O.C_6H_4OH$)	H_2O	*3*		−63.84	(211); *cf.* (851)
		H_2O			−64.7	(215)
$C_{12}H_{16}O_7$	Resorcinol-*d*-glucoside	H_2O	*7.952*	23	−70.41	(550)
$C_{12}H_{16}O_8$	Phloroglucinol-*d*-glucoside	Py	*7.008*	20	−74.79	(550)
		Py	*8.780*	22	−74.58	
		H_2O	3.10	20	−24.20	(2077)
		EtOH	5.25	20	−24.95	
$C_{12}H_{22}O_6$	β-Cyclohexanol-*d*-glucoside	H_2O	*9.800*	20	−41.43	(508.5)
$C_{13}H_{16}O_7$	Glucosido-*p*-hydroxybenzaldehyde	H_2O	*2.18*	21	−94.45	(1404.5)
$C_{13}H_{16}O_8$	Glucosido-*m*-hydroxybenzoic acid	EtOH			−68.41	(1404.8)
$C_{13}H_{16}O_{10}$	β-Glucosidogallic acid	H_2O	*9.670*	20	−21.3	(551)
$C_{13}H_{17}NO_8$	*m*-Nitrobenzyl-β-glucoside	H_2O	1.43	18	−52.59	(221)
$C_{13}H_{18}O_6$	β-Benzyl-*d*-glucoside ($C_6H_{11}O_5.OCH_2.C_6H_5$)	H_2O	1.255		−49.78	(192); *cf.* (508.5)
$C_{13}H_{18}O_7$	Arbutin methyl ether	H_2O			−63.43	(215)
$C_{13}H_{18}O_7$	Salicin (salicyl-β-glucoside, $C_6H_{11}O_5.O.C_6H_4.CH_2.OH$)	H_2O	1.6		−37.5	(216)
		H_2O	*0.972*		−65.15	(194)
		40% EtOH	*1.004*		−53.14	
		85% EtOH	*0.976*		−49.82	
$C_{13}H_{21}O_9$	Aucubin	H_2O	*4.24*		−174.4	(213)
$C_{13}H_{21}O_9.H_2O$	Hydrated	H_2O	*4.24*		−164.9	(213)
$C_{13}H_{22}O_7$	Taxicatin	95% EtOH	1.71		−67.25	(1185)
		H_2O	1		−71.65	
$C_{14}H_{17}NO_6$	Sambunigrin ($C_6H_{11}O_5.O.CH(CN).C_6H_5$)	H_2O?	1.16		−76.3	(210)
$C_{14}H_{18}O_7.H_2O$	Glucosido-*p*-hydroxyacetophenone ($C_6H_{11}O_5.O.C_6H_4.CO.CH_3$)	H_2O			−88.87	(1404.8)
$C_{14}H_{20}O_6$	Phenethyl-*d*-β-glucoside ($C_6H_{11}.OCH_2.CH_2.C_6H_5$)	H_2O	2.02		−23.92	(201)
	m-Hydroxymethylbenzylmono-β-glucoside	H_2O	1.747		−46.86	(222, 223)
$C_{14}H_{20}O_7$	*p*-Hydroxymethylbenzylmono-β-glucoside ($C_6H_{11}O_5.OCH_2.C_6H_4.CH_2OH$)	H_2O	2.317		−50.47	
$C_{14}H_{20}O_7$	*o*-Methoxybenzyl-β-glucoside	H_2O	1.18	18	−52.24	(221)
	p-Methoxybenzyl-β-glucoside ($C_6H_{11}O_5.OCH_2.C_6H_4.OCH_3$)	H_2O	1.0	18	−53.33	(221)
$C_{15}H_{20}O_6$	Cinnamyl-*d*-β-glucoside ($C_6H_{11}O_5.OCH_2.CH:CH.C_6H_5$)	H_2O	2.142		−46.46	(201)
$C_{16}H_{28}O_5$	Anhydromenthylglucoside	EtOH	*11.25*	25	−96.50	(559)
$C_{16}H_{28}O_6$	*d*-Bornylglucoside ($C_6H_{11}O_5.O.C_{10}H_{17}$)	EtOH	*8.1*	20	−42.1	(539)
$C_{16}H_{30}O_6$	Menthylglucoside ($C_6H_{11}O_5.O.C_{10}H_{19}$)	EtOH	*8.18*	20	−93.0	(539)
$C_{18}H_{28}O_7$	Pentamethylsalicin	MeOH	4.7	20	−52.15	(982)

Aromatic and hydroaromatic glucosides (with some glucosides of unknown structure).—(Continued)

Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{19}H_{20}O_7$	Glucosido-*p*-hydroxybenzophenone ($C_6H_{11}O_5.O.C_6H_4.CO.C_6H_5$)	EtOH			−55.58	(1404.8)
$C_{19}H_{22}O_7$	Arbutin benzyl ether	EtOH		17	−44.47	(215)
$C_{19}H_{23}BrO_8$	Triacetylbenzylglucosidebromohydrin	$CHCl_3$	*6.998*	20	−46.76	(559)
$C_{20}H_{21}Br_3O_{10}$	Tribromo-2, 4, 6-phenol-tetraacetyl-*d*-glucoside	Py	*9.497*	25	−8.89	(550)
$C_{20}H_{24}O_9S$	Tetraacetylphenylthiolglucoside	PhMe	*5.05*	20	−40.1	(498)
$C_{20}H_{24}O_{10}$	Tetraacetylphenol-*α*-glucoside	C_6H_6	*8.75*	20	165.4	(525); *cf.* (488)
	Tetraacetylphenol-*β*-glucoside	C_6H_6	*1.09*	20	−28.9	
$C_{20}H_{30}O_{10}$	Tetraacetyl-*β*-cyclohexanol-*d*-glucoside	EtOH	*2.076*	22	−29.74	(508.5)
$C_{21}H_{24}O_7$	*p*-Toluylidenesalicin	MeOH	*0.4*		−16	(421)
$C_{21}H_{24}O_{11}$	Tetraacetylhelicin	C_6H_6	*5.69*	20	−23.48	(548)
		Me_2CO	*10.9*	20	−37.15	
$C_{21}H_{26}O_{10}$	Tetraacetyl-*β*-benzyl-*d*-glucoside	EtOH	*2.072*	22	−49.51	(508.5)
$C_{22}H_{25}NO_{11}$	Tetraacetylhelicincyanohydrin	Me_2CO	*10.9*	20	−24.32	(548)
$C_{22}H_{35}BrO_8$	Triacetylmenthyl-*d*-glucosidebromohydrin	$CHCl_3$	*9.396*	20	−49.75	(559)
$C_{23}H_{28}O_{14}$	Ethyl tetraacetylglucosidogallate	$C_2H_2Cl_4$	*6.207*	20	−10.66	(551)
		$C_2H_2Cl_4$	*6.294*	20	−10.63	
$C_{24}H_{34}O_5$	Sapogenine	EtOH	0.9190	18	90.86	(1798)
	Heterocyclic glucosides					
$C_{11}H_{13}Cl_2N_5O_5$	2, 8-Dichloroadenine-*d*-glucoside	H_2O	0.434	20	9.2	(509)
$C_{11}H_{14}ClN_5O_5$	Chloroadenine-*d*-glucoside	H_2O	0.914	20	−7.66	(509)
$C_{11}H_{14}N_4O_6$	Hypoxanthine-*d*-glucoside	*N* NaOH	*6.8*	20	−34.50	(509)
		N HCl	*6.9*	20	12.92	
		H_2O	*5*	20	0	
$C_{11}H_{15}N_5O_5$	Adenine-*d*-glucoside (6-Aminopurine-*d*-glucoside)	H_2O	*3.215*	19	−10.50	(509)
		N HCl	*6.12*	20	5.51	
$C_{11}H_{15}N_5O_6$	Guanine-*d*-glucoside	*N* NaOH	*7.4*	15	−41.94	(509)
		N NaOH	*7.7*	15	−41.34	
$C_{13}H_{17}ClN_4O_7$	Chlorotheophylline-*d*-glucoside	H_2O	*6.3*	20	18.88	(509)
$C_{13}H_{18}N_4O_7$	Theobromine-*d*-glucoside	H_2O	*3.881*	20	−49.58	(509)
	Theophylline-*d*-glucoside	*N* HCl	*8.8*	20	1.08	
		H_2O	*9.18*	20	−2.33	
$C_{19}H_{19}Cl_3N_4O_9$	Tetraacetyltrichloropurine-*d*-glucoside	$C_2H_2Cl_4$	*6.2*	19	−26.48	(509)
$C_{19}H_{21}Cl_2N_5O_9$	Tetraacetyl-2, 8-dichloro-6-aminopurine-*d*-*β*-glucoside	$C_2H_2Cl_4$	*2.5*	17	−16.52	(509)
$C_{21}H_{25}ClN_4O_{11}$	Tetraacetylchlorotheophylline-*d*-*β*-glucoside	PhMe	*7.360*	21	−15.95	(509)
$C_{21}H_{26}N_4O_{11}$	Tetracetyltheobromine-*d*-*β*-glucoside	$C_2H_2Cl_4$	*5.9*	20	−18.42	(509)
$C_{21}H_{26}N_4O_{11}$	Tetraacetyltheophylline-*d*-glucoside	$C_2H_2Cl_4$	*5.9*	20	−12.36	(509)
$C_{22}H_{28}N_4O_{12}$	Tetracetylhydroxycaffeine-*d*-*β*-glucoside	$C_2H_2Cl_4$	*4.0*	25	1.81	(509)
$C_{25}H_{35}ClN_2O_7$	Dihydrocupreineglucoside hydrochloride	H_2O	*2.69*	20	−160	(1037)
$C_{32}H_{40}N_2O_{19}S$	2-Thiouracildi-[tetraacetylglucoside]	$C_2H_2Cl_4$	*7.20*	19.5	12.59	(485)
$C_{33}H_{43}ClN_2O_{11}$	Dihydrocupreinetetraacetyl-*d*-glucoside hydrochloride	H_2O	*4.43*	18	−1.88	(1037)
	Nitrogen derivatives of glucose: Oxime, osazone, etc.					
$C_6H_{13}NO_6$	Glucosoxime	H_2O	*10*	20	−2.2*	(107); *cf.* (992)
$C_7H_{14}N_2O_5S$	Glucose thiocarbamide	H_2O	9.010	20	−35.73	(485)
$C_7H_{14}N_2O_6$	Glucose carbamide	H_2O	*7.861*	19	−23.41	(485)
$C_7H_{15}N_3O_6$	Glucose semicarbazone	H_2O	2.5		−9*	(1375)
$C_{12}H_{18}N_2O_5$	Glucose *α*-phenylhydrazone	H_2O	4.0	19	−80.7	(1992); *cf.* (108, 993)
	Glucose *β*-phenylhydrazone	H_2O	*5*		−50*	(107); *cf.* (108)
$C_{18}H_{22}N_4O_4$	Glucosazone (initial)	Py	0.8		−104	(1992)
	Nitrogen derivatives of glucose: Glucosamine, epiglucosamine and derivatives					
$C_6H_{13}NO_5$	Glucosamine	H_2O	4.605		22.6*	(987)
		MeOH aq	1.932		21.2*	
$C_6H_{12}ClNO_4$	Anhydroepiglucosamine hydrochloride	2.5% HCl	1	20	−172	(1235)
$C_6H_{14}BrNO_5$	Glucosamine hydrobromide	H_2O	*5.312*	20	60.23	(2023)
$C_6H_{14}ClNO_5$	Glucosamine hydrochloride	H_2O	*5.158*	20	74.64	(2157)
		H_2O	*2.593*	20	70.61	
		H_2O	*22.555*	20	59.37	

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* Mutarotation.

Nitrogen derivatives of glucose: Glucosamine, epiglucosamine and derivatives.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_7H_{15}NO_5$	α-Aminomethylglucoside	MeOH	2.703	20	−16.65	(969)
		MeOH	2.572	20	−14.8	
$C_7H_{16}BrNO_5$	Hydrobromide	H_2O	2.432	20	−20.2	(969)
$C_7H_{16}ClNO_5$	Hydrochloride	H_2O	8.985	20	−24.2	(969, 971)
$C_7H_{16}BrNO_5$	β-Aminomethylglucoside hydrobromide	H_2O	*9.005*	20	−21.2	(558)
$C_7H_{16}ClNO_5$	β-Aminomethylglucoside hydrochloride	H_2O	*9.661*	20	−25.1	(558)
$C_7H_{16}ClNO_5$	Methylepiglucosamine hydrochloride	2.5% HCl	1	20	−138	(1235)
$C_8H_{17}NO_5$	Ethylaminoglucose	EtOH	0.770		−12.3*	(987)
$C_8H_{17}NO_5$	α-Monomethylaminomethylglucoside	MeOH	2.0	20	−14.95	(969)
		H_2O	2.0	20	−12.99	
$C_8H_{18}ClNO_5$	Aminoethylglucoside hydrochloride	H_2O	2.685	20	−27.7	(971)
$C_9H_{17}NO_7$	Ethyl glucosaminecarboxylate	H_2O	*14.85*	10.25	33.18	(572)
$C_9H_{19}NO_7$	Methylepiglucosamine acetate	2.5% HCl	1	20	−130	(1235)
$C_{10}H_{18}N_2O_7$	Succinamide-*d*-glucoside	H_2O	*8.453*	18	−17.35	(485)
	($C_6H_{11}O_5$.NH.CO.CH_2.CH_2.CO.NH_2)	H_2O	*7.720*	19	−17.40	
$C_{12}H_{19}Br_2NO_7$	Bromotriacetylglucosamine hydrobromide	Me_2CO	5.01		148.4*	(976)
		AcOEt	1.096		152.8	
$C_{13}H_{18}ClNO_6$	α-Aminohelicin hydrochloride	H_2O		20	−9.0	(971)
$C_{13}H_{20}ClNO_6$	Aminobenzylglucoside hydrochloride	H_2O	1.0	20	−51.2	(971)
$C_{13}H_{20}ClNO_6$	α-Aminosalicin hydrochloride	H_2O	3.606	20	−19.0	(971)
$C_{13}H_{22}BrNO_8$	Triacetylmethylglucosamine hydrobromide	MeOH	2.098		20.26	(976)
		H_2O	1.24		20.56	
$C_{13}H_{22}BrNO_8$	Triacetyl-α-aminomethylglucoside hydrobromide	MeOH		20	20.3	(971)
$C_{14}H_{24}BrNO_8$	Triacetyl-α-aminoethylglucoside hydrobromide	MeOH	1.806	20	12.5	(971)
$C_{16}H_{25}NO_{11}$	Glucosamine α-pentaacetate	$CHCl_3$	2.55	20	93.5	(944)
	Glucosamine β-pentaacetate	$CHCl_3$	4.4	20	1.3	
$C_{17}H_{25}NO_5.H_2O$	Tetramethylglucose-*p*-toluidide	MeOH	1.09	20	53.5*	(968)
$C_{17}H_{25}NO_{10}S$	Tetracetylglucosothiourethane ($C_6H_7O(OCOCH_3)_4$.NH.CS.OC_2H_5)	$C_2H_2Cl_4$	*5.88*	21	11.53	(485)
$C_{17}H_{30}BrNO_8$	Triacetyl-α-aminoamylglucoside hydrobromide	MeOH	1.687	20	10.4	(971)
$C_{18}H_{23}NO_{11}$	Tetraacetylsuccinimide-*d*-glucoside	$C_2H_2Cl_4$	*6.170*	18	12.81	(485)
	($C_6H_7O(OCOCH_3)_4$.$NC_4H_4O_2$)	$C_2H_2Cl_4$	*5.351*	18	12.73	
$C_{19}H_{24}BrNO_9$	Triacetyl-α-aminohelicin hydrobromide	MeOH		20	43.6*	(971)
$C_{19}H_{26}BrNO_8$	Triacetyl-α-aminobenzylglucoside hydrobromide	MeOH	1.372	20	52.1	(971)
$C_{23}H_{30}N_2O_7$	α-Aminomorphineglucoside	H_2O	1.0	20	−113.5	(971)
$C_{41}H_{33}NO_{10}$	Pentabenzoylglucosamine	Py	*2.61*	20	44.4	
	Nitrogen derivatives of glucose: Glucosanilide, etc.					
$C_9H_{17}NO_7$	Glucosanil	H_2O	1.00	20	45.7	(968)
$C_{12}H_{17}NO_5$	Glucosanilide	MeOH	*5.029*	21.0	−48.32	(1976); *cf.* (964)
		MeOH	*3.326*	21.0	−49.15	
		90% EtOH	*4.697*	21.0	−44.08	
		90% EtOH	*3.269*	21.0	−44.15	
$C_{13}H_{17}NO_7.H_2O$	Glucose-*o*-carboxyanilide	MeOH	2.5	20	−14.5*	(965)
$C_{13}H_{19}NO_5$	Glucose-*p*-toluidide	MeOH	2.0	20	181.9	(965)
		MeOH	*7.879*	23.0	−43.88	(1976)
		MeOH	*2.613*	23.0	−38.23	
		90% EtOH	*6.658*	23.0	−38.80	
$C_{13}H_{19}NO_5$	ζ-Monomethylglucoseanilide	MeOH	0.636	20	−49.0*	(966)
$C_{14}H_{21}NO_6.H_2O$	Glucose-*p*-phenetidide	MeOH	3.47	20	−38.3	(965)
$C_{16}H_{19}NO_5.H_2O$	Glucose-β-naphthylamide	MeOH	2.5	20	−48.1*	(965)
$C_{16}H_{25}NO_5$	Tetramethylglucosanilide	MeOH		20	47.0*	(964)
	Mannose and derivatives					
$C_{10}H_{20}O_6$	Tetramethylmannose	H_2O	5	20	1.2*	(977)
		MeOH	5	20	17.2*	
$C_{11}H_{22}O_6$	Tetramethyl α-methylmannoside	H_2O	9.99	20	42.9	(977); *cf.* (837)
		MeOH	10.0	20	70.5	
		EtOH	7.95	20	75.5	
$C_{12}H_{20}O_6$	Diisopropylidenemannose	$C_2H_2Cl_4$	*9.03*	19	14.3*	(669)
$C_{13}H_{22}O_6$	Diisopropylidenemethylmannose	$C_2H_2Cl_4$	*9.17*	19	−41.0*	(669)

* Mutarotation.

Mannose and derivatives.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{15}H_{20}O_6$	*p*-Toluylidene *α*-methylmannoside	MeOH			29.5	(421)
$C_{15}H_{22}O_{10}$	*α*-Tetraacetylmethyl-*d*-mannoside	$CHCl_3$	4.43	20	49.1	(366)
	β-Tetraacetylmethyl-*d*-mannoside	$CHCl_3$	1.28	20	−47.0	
	γ-Tetraacetylmethyl-*d*-mannoside	$CHCl_3$	4.15	20	−26.6	
$C_{16}H_{22}O_{11}$	*α*-Pentaacetylmannose	$CHCl_3$	4.7	20	55.0	(943)
		H_2O	2.5	17	57.6	(1228)
	β-Pentaacetylmannose	$CHCl_3$	8.3	20	−25.2	
		$CHCl_3$	*8.06*	20	−24.9	
$C_{21}H_{22}O_6$	Dibenzylidene-*α*-methylmannoside	$CHCl_3$	0.4		−5	(421)
$C_{41}H_{32}O_{11}$	Pentabenzoylmannose	$CHCl_3$	*8.92*	20	−80.44	(528)
$C_{51}H_{42}O_{11}$	Pentacinnamylmannose	C_6H_6	*9.98*	20	−99.9	(528)
Nitrogen derivatives of mannose						
$C_6H_{13}NO_6$	Mannose oxime ($H(CHOH)_5CH{:}NOH$)	H_2O	4.798	20	3.2*	(992)
$C_6H_{15}NO_5$	Mannamine ($H(CHOH)_5.CH_2.NH_2$)	H_2O	*10*		−2	(1804.5)
$C_7H_{15}N_3O_6$	Mannose semicarbazone	H_2O	40		−43*	(1375)
$C_{12}H_{17}NO_5$	Mannoseanilide	Py	2.0	20	−81.5*	(975)
$C_{13}H_{17}NO_7$	Mannose-*o*-carboxyanilide	MeOH	2.04	20	−21.1*	(968)
$C_{14}H_{32}N_2O_{14}$	Dimannamine oxalate	H_2O	*10*		4.25	(1804.5)
$C_{16}H_{25}NO_5$	Tetramethylmannoseanilide	MeOH	2.10	20	−8.3*	(975)
Galactose and alkyl, alkylidene and acyl derivatives						
$C_6H_{12}O_6$	Galactose	H_2O	*50*	14.6	84.23	(1598)
		H_2O	*9.09*	20	80.8	(845)
		Py	*0.62*		55.6†	
$C_8H_{16}O_6$	Galactite (*α*-ethylgalactoside)	H_2O	*10.42*	19	186.2	(484)
$C_{10}H_{20}O_6$	Tetramethylgalactose	H_2O	1.766		84.9	(1722)
		H_2O	10	20	109.5	(961)
		EtOH	10	20	62.6	
		C_6H_6	10	20	90.0	
$C_{11}H_{22}O_6$	Pentamethylgalactose	EtOH	7.65	20	21.5	(961)
$C_{12}H_{20}O_6$	Diisopropylidenegalactose	$C_2H_2Cl_4$	9.21		−60.9†	(669)
$C_{13}H_{22}O_6$	Diisopropylidenemethylgalactose	$C_2H_2Cl_4$	1.07	19	63.2†	(669)
$C_{14}H_{19}BrO_9$	*β*-Tetraacetylbromogalactose	C_6H_6	*9.89*	20	236.4	(489)
$C_{14}H_{19}ClO_9$	Tetraacetylchlorogalactose	$CHCl_3$	6.2	20	−79.1	(947)
$C_{14}H_{19}NO_{12}$	Tetraacetylnitrogalactose	$CHCl_3$	*5.26*	20	153.2	(1118)
$C_{14}H_{20}O_{10}$	Tetraacetylgalactose	$CHCl_3$	3.96	25	137.17	(1962)
$C_{14}H_{20}O_{10}$	Galactose tetraacetate	$CHCl_3$	4.7	20	−17.8	(947)
		C_6H_6	3.5	20	−23.4	
		AcOH	4.1	20	−11.0	
		H_2O	4.4	20	−12.9	
$C_{16}H_{22}O_{11}$	Galactose pentaacetate (M. P. 142)	$CHCl_3$		20	25	(937)
	(M. P. 95–96°)	$CHCl_3$		20	107	
	(M. P. 98°)	$CHCl_3$		20	−41.6	
	Galactose pentaacetate (1st isomeride)	$CHCl_3$			23	(947); *cf.* (695, 845)
	(2nd isomeride)	$CHCl_3$			107	
	(3rd isomeride)	$CHCl_3$			−42	
	(4th isomeride)	$CHCl_3$	4.28		61	
		C_6H_6	3.52		44.8	
		AcOH	3.04		62.4	
		Ac_2O	3.08		70.2	
$C_{19}H_{26}O_8S$	Diisopropylidenegalactose toluene-*p*-sulfonate	$C_2H_2Cl_4$	*9.16*		−64.7*	(669)
Galactosides						
$C_7H_{14}O_6$	*α*-Methyl-*d*-galactoside	H_2O	0.983		192.7	(181.5); *cf.* (465.5)
	β-Methyl-*d*-galactoside	H_2O	4.05		−0.42	
	β-Methylgalactoside	H_2O	4.05		0	(199); *cf.* (181, 202)
$C_8H_{16}O_6$	*α*-Ethyl-*d*-galactoside	H_2O	1.20		185.4	(181.5)
	β-Ethyl-*d*-galactoside	H_2O	4.57		−4.00	(490)
		H_2O	49.0	20	−7.21	(224)
		H_2O	0.85		185.5	(852); *cf.* (465.5, 484)

* $[\alpha]_{5790}$. † Mutarotation.

Galactosides.—(Continued)

Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_3H_{16}O_6$	β-Ethylgalactoside	H_2O	2		−4.0	(**193, 197**); *cf.* (**224**)
$C_8H_{16}O_7$	Ethyleneglycol-α-monogalactoside	H_2O		20	169.9	(**27, 209**)
	Ethyleneglycol-β-monogalactoside	H_2O			0	(**206.5, 208**)
$C_8H_{16}O_7$	Ethyleneglycolmono-*d*-β-galactoside	H_2O	2.63	20	0	(**181.5**)
	Ethyleneglycolmono-*d*-α-galactoside	H_2O	1.78	20	169.9	
$C_8H_{16}O_7$	Glycol-α, β-monogalactoside ($C_6H_{11}O_6.CH_2.CH_2OH$)	H_2O	2.6	17.5	0	(**208**)
	Glycol-*d*-α-monogalactoside	H_2O	1.78	18	169.9	(**209**)
$C_9H_{16}O_6$	β-Allyl-*d*-galactoside	H_2O	2.74		−12.15	(**181.5**); *cf.* (**196**)
$C_9H_{18}O_6$	β-Propylgalactoside	H_2O	2.26		−8.86	(**218**); *cf.* (**181.5**)
$C_9H_{18}O_6$	α-Propyl-*d*-galactoside	H_2O	1.87	20	179.0	(**181.5**); *cf.* (**185**)
$C_{10}H_{20}O_6$	β-Isobutyl-*d*-galactoside	H_2O	2.9		−11.23	(**181.5**); *cf.* (**203**)
$C_{11}H_{22}O_6$	2, 3, 5, 6-Tetramethyl-β-methylgalactoside	H_2O	0.9872	20	19.59	(**1875**)
$C_{11}H_{22}O_6$	Tetramethyl-α-methylgalactoside	EtOH	10.25	20	109.9	(**961**)
		H_2O	10.02	20	143.4	
	Tetramethyl-β-methylgalactoside	H_2O	1.311		4.4	(**1722**)
$C_{12}H_{16}O_6$	β-Phenol-*d*-galactoside	H_2O	*4.45*	20	−39.38	(**489**)
$C_{13}H_{18}O_6$	β-Benzyl-*d*-galactoside	H_2O	2.99		−25.05	(**181.5**); *cf.* (**218**)
$C_{14}H_{18}O_6$	Benzylidene-α-methylgalactoside	MeOH	*1*		120.7	(**421**)
$C_{15}H_{20}O_6$	*p*-Toluylidene-α-methylgalactoside	MeOH	*0.4*		14.2	(**421**)
$C_{15}H_{22}O_{10}$	Tetraacetyl-β-methylgalactoside	C_6H_6	10.0	17	−25.47	(**1118**)
$C_{16}H_{24}O_{10}$	Tetraacetyl-β-ethylgalactoside	C_6H_6	*10*	20	−29.8	(**490**)
$C_{20}H_{24}O_{10}$	Tetraacetyl-β-phenolgalactoside	C_6H_6	*7.47*	20	−25.77	(**489**)
	Nitrogen derivatives of galactose					
$C_6H_{13}NO_5$	Galactamine ($H(CHOH)_5.CH.NH_2$)	H_2O	*10*		−2.77	(**1802**)
$C_6H_{13}NO_6$	Galactose oxime ($H(CHOH)_5.CH{:}NOH$)	H_2O	5.106	20	14.75*	(**992**)
$C_7H_{15}N_3O_6$	Galactose semicarbazone (after 48 hr.)	H_2O	40		16†	(**1375**)
$C_{12}H_{17}NO_5$	Galactoseanilide	90% EtOH	*2.289*	20	−31.33	(**1976**)
		MeOH	*1.699*	21	−33.12	
		EtOH	*0.6167*	21	−33.99	
		90% EtOH	2.3	20	−6.93†	(**975**)
		MeOH	0.507	20	−31.6†	
$C_{12}H_{18}N_2O_5$	Galactose phenylhydrazone	H_2O	1.98	20	−20.6	(**993**); *cf.* (**553**)
$C_{13}H_{17}NO_7$	Galactose-*o*-carboxyanilide	MeOH	1.16	20	4.3†	(**968**)
$C_{13}H_{19}NO_5$	Galactose-*p*-toluidide	MeOH	0.9832	21	−10.91	(**1976**)
$C_{14}H_{28}N_2O_{14}.2H_2O$	Galactamine normal oxalate	H_2O	*8*		−11.28	(**1802**)
$C_{16}H_{25}NO_5$	Tetramethylgalactoseanilide	Me_2CO	1.0	20	37.7†	(**975**)
$C_{18}H_{22}N_4O_4$	Galactosazone	Py	0.8	19	121	
$C_{24}H_{40}N_2O_{10}$	*asym.*-Di-(diacetonegalactosyl)-hydrazone	$C_2H_2Cl_4$	*5.58*	15	−77‡	(**669**)
$C_{48}H_{76}N_4O_{20}$	Tetra-(diacetonegalactosyl)-tetrazone	$C_2H_2Cl_4$	*3.29*	15	−76.3‡	(**669**)
	Other hexoses					
$C_6H_{12}O_6$	Cocaose	H_2O	3.98	15	19.8	(**895**)
$C_{16}H_{18}NO_{10}$	Epichitosamine pentaacetate	$CHCl_3$	3	20	−18	(**1224**)
	SUGAR ACIDS CONTAINING 6 CARBON ATOMS					
	Acids derived from methylpentoses					
$C_6H_{10}O_5$	Isorhamnonic acid lactone	H_2O	*8.903*	20	−62.02	(**510**)
$C_6H_{10}O_5$	Fuconic acid lactone	H_2O	1.64		78.3	(**1479**)
$C_{41}H_{33}NO_{10}$	Pentabenzoylxylohexosamine	Py	*2.83*	20	77.6	(**1222**)
	Gluconic acid and related compounds					
$C_6H_{12}O_6$	Glucodesonic acid ($H(CHOH)_4.CH_2.COOH$)	H_2O	*4.68*	17	4.30	(**112**)
	Barium salt	H_2O	*1.10*	19	13.37	(**112**)
$C_6H_8O_5$	Anhydrogluconic lactone	H_2O	*9.13*	20	82.3	(**560**)
$C_6H_{10}O_6$	*d*-Gluconic α-lactone	H_2O	*4.00*	20	67.8	(**844**); *cf.* (**456.5, 857.5**)
	d-Gluconic β-lactone	H_2O	*4.55*	20	63.4	

* Calculated on weight of acid. † Mutarotation. ‡ $[\alpha]_{5461}$.

Gluconic acid and related compounds.—(Continued)

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_6H_{11}NO_5$	Anhydrogluconic amide	H_2O	*9.11*	20	77.7	(560)
$C_6H_{12}O_7$	*d*-Gluconic acid, calcium salt	H_2O	*4.93*	20	10.55	(1490)
	Sodium salt	H_2O	20.8	20	11.78	(1234)
$C_8H_{16}O_7$	Ethyl *d*-gluconate ($H(CHOH)_5.CO.OC_2H_5$)	H_2O	4	20	−1.0	(844)
$C_{10}H_{18}O_6$	Tetramethylgluconic lactone	EtOH aq.	2.41		39.5*	(1733); *cf.* (962)
$C_{14}H_{18}O_{10}$	Tetraacetyl-*d*-gluconic lactone	C_6H_6	10.5	21	70.86	(1549)
$C_{29}H_{38}N_2O_{11}$	Brucine *d*-gluconate	H_2O	*2.4*	20	−15.95	(1234)
	Galactonic acid					
$C_6H_{10}O_6$	Galactonic lactone	H_2O	0.786		−69.97	(1722); *cf.* (1226, 1881.5)
	Galactonic γ-lactone	H_2O	4.5	20	−76.97	(844)
	Hydrate	H_2O	4.5	20	−70.1	
$C_6H_{12}O_7$	Galactonic acid	H_2O	1.1015		−57.57*	(1722)
	Sodium salt	H_2O	10.02	20	0.4	(1234)
$C_8H_{12}O_7.2H_2O$	Dimethylenegalactonic acid	H_2O	0.645		45.3	(334)
$C_{10}H_{18}O_6$	*l*-2, 3, 5, 6-Tetramethylgalactonic lactone	H_2O	1.413		−26.96*	(1722)
	d-2, 3, 5, 6-Tetramethylgalactonic lactone	H_2O	1.202		16.9*	
$C_{11}H_{22}O_7$	Methyl *d*-2, 3, 5, 6-tetramethylgalactonate	H_2O	1.773		9.93	(1722)
$C_{14}H_{18}O_{10}$	Tetraacetyl-*d*-galactonic lactone	C_6H_6	*13.19*	20	1.04	(1722)
	(Prepared by another method)	C_6H_6	*17.47*	20	8.5	
$C_{29}H_{38}N_2O_{11}$	Brucine galactonate	H_2O	*2.5*	20	−21.01	(1234)
	Isomers of gluconic and galactonic acids					
$C_6H_{10}O_6$	Chitaric acid	H_2O	3	0	63.0	(1227)
	Calcium salt	H_2O	*3*	17	63.0	(1227)
$C_6H_{12}O_7$	Allonic acid	H_2O	2.5	20	−10.0	(1226)
	Sodium salt	H_2O	10.02	20	4.3	(1234)
$C_6H_{12}O_7$	Altronic acid	H_2O	2.5	20	−8.0	(1226)
	Sodium salt	H_2O	7.78	20	−4.05	(1234)
$C_6H_{12}O_7$	Chitonic acid	H_2O	3	8.5	38.3	(1227)
	Calcium salt	H_2O	3	17	30.3	(1227); *cf.* (1234)
$C_6H_{12}O_7$	Gulonic acid	H_2O	2.5	0	1.6	(1226)
	Sodium salt	H_2O	9.38	20	12.68	(1234)
$C_6H_{12}O_7$	Idonic acid, sodium salt	H_2O	8.22	20	−2.52	(1234)
$C_6H_{12}O_7$	Mannonic acid	H_2O	2.5	0	15.6	(1226); *cf.* (514, 1061)
	Sodium salt	H_2O	9.52	20	−8.82	(1234)
$C_7H_{10}O_6$	Monomethylene-*d*-mannonic acid lactone	H_2O	1.022		91	(334)
$C_{29}H_{36}N_2O_{10}$†	Brucine chitarate	H_2O	*2.5*	20	−2.96	(1234)
$C_{29}H_{38}N_2O_{11}$	Brucine allonate	H_2O	*2.5*	0	−21.28	(1234)
$C_{29}H_{38}N_2O_{11}$	Brucine altronate	H_2O	*2.477*	20	−23.85	(1234)
$C_{29}H_{38}N_2O_{11}$	Brucine chitonate	H_2O	*2.5*	20	−8.47	(1234)
$C_{29}H_{38}N_2O_{11}$	Brucine gulonate	H_2O	*2.6*	20	−19.59	(1234); *cf.* (1226)
$C_{29}H_{38}N_2O_{11}$	Brucine idonate	H_2O	*2.5*	20	−25.79	(1234)
$C_{29}H_{38}N_2O_{11}$	Brucine mannonate	H_2O	*2.6*	20	−25.7	(1234)
$C_{29}H_{38}N_2O_{11}$	Brucine talonate	H_2O	*2.5*	20	−26.15	(1234)
	Glucuronic acid and isomers					
$C_6H_{10}O_7$	Glucuronic acid, potassium salt ($CHO.(CHOH)_4.COOK$)	H_2O	*3.85*	18	21.25	(225, 1138.8, 2008)
$C_{12}H_{14}O_7$	Phenylglucuronate ($CHO.(CHOH)_4.CO.OC_6H_5$)	EtOH	3.00	17	−83.3	(1507)
$C_{13}H_{14}O_8$	Benzoylglucuronic acid, sodium salt	H_2O	*3.25*	20	43.86	(1358)
$C_{16}H_{28}O_7$	Mentholglucuronic acid	EtOH	0.765	20	104.1	(482)
		EtOH	4.72	18	51.9	(113)
$C_{19}H_{18}O_{11}$	Isoeuxanthic acid	70% EtOH	0.613		−87.4	(1507)
	Euxanthic acid‡	70% EtOH	0.482		−108	

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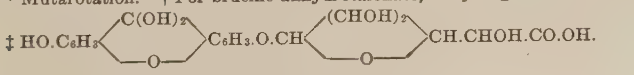
* Mutarotation. † For brucine anhydrotalonate, anhydrogalactonate and lyxohexosamate, *see* p. 474.



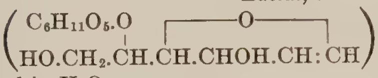
‡ $HO.C_6H_3\langle C(OH)_2 \cdot O \rangle C_6H_3.O.CH\langle (CHOH)_2 \cdot O \rangle CH.CHOH.CO.OH.$

Saccharic and saccharinic acids and isomers

Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_6H_8O_6.H_2O$	Saccharone	H_2O	*12.41*	18	−6.1	(**1057**)
$C_6H_8O_7$	*r*-Saccharic acid lactone	H_2O	18	18	40.77	(**1421**); *cf.* (**264, 1974**)
	d-Ammonium salt	H_2O	20.03		5.84	(**1974**)
$C_6H_8O_7$	Isosaccharic acid lactone	H_2O	4.266	20	46.12	(**2024**)
$C_6H_8O_7.2H_2O$	*d*-Mannosaccharic acid anhydride	H_2O	3.432	23	201.8	(**457**)
$C_6H_{10}N_2O_5$	Isosaccharic diamide anhydride	H_2O	5		7.16	(**2024**)
	Saccharine (glucosaccharinic acid lactone)	H_2O	10.4	20	88.7*	(**1881**)
		H_2O	*12.08*	17.5	93.08	(**1596**); *cf.* (**854, 1861**)
$C_6H_{10}O_5$	Metasaccharin (from calcium metasaccharinate ($(C_6H_{11}O_6)_2Ca.2H_2O$)	H_2O	*7.846*	14	−48.4	(**1058**)
		H_2O	7.0		−46.96	(**1881**)
	Isosaccharin (from calcium isosaccharinate)	H_2O	*9.47*		61.88	(**2158**)
		H_2O	10	10	62.97	(**1881**)
$C_6H_{10}O_8$	Talomucic acid	H_2O	*3.84*	20	−29.4	(**460**)
$C_6H_{10}O_8$	*r*-Saccharic acid ($(CHOH)_4(COOH)_2$)	H_2O	18	18	9.05	(**1421**)
$C_{10}H_{16}O_7$	Diethyl isosaccharide anhydride	H_2O	5		35.5	(**2027**)
	Amino acids					
$C_6H_{13}NO_6$	*l*-Glucosamic acid ($H(CHOH)_4.CHNH_2.COOH$)	2.5% HCl	*8.82*	18	14.31	(**522**)
$C_6H_{13}NO_6$	*d*-Chondrosamic acid	2.5% HCl	*4*	20	−16.15	(**1223**)
	After addition of *M* Py	2.5% HCl	*4*	20	−4.83	
	d-Glucosamic acid	2.5% HCl	*4*	20	−15.02	
	After addition of *M* Py	2.5% HCl	*4*	20	2.11	
$C_6H_{13}NO_6$	*d*-Lyxohexosamic acid	2.5% HCl	*4*	20	−3.58	
	After addition of *M* Py	2.5% HCl	*4*	20	−6.98	
	d-Xylohexosamic acid	2.5% HCl	*4*	20	11.77*	
	After addition of *M* Py	2.5% HCl	*4*	20	15.47	
	SUGARS, ETC., CONTAINING 7 CARBON ATOMS					
	Acids with 7 carbon atoms					
$C_7H_{10}O_6$	Rhamnoheptonic acid anhydride	H_2O	10.036	20	55.6	(**1971**)
$C_7H_{10}O_8$	β-Pentahydroxypimelic acid anhydride	H_2O	*9.972*	20	68.5	(**461**)
$C_7H_{12}O_6$	Fucohexonic lactone	H_2O	1.56		33.3	(**1408**)
$C_7H_{12}O_7$	α-Glucoheptonic lactone	H_2O	10	25	−43.73*	(**1616**); *cf.* (**1059**)
	β-Glucoheptonic lactone	H_2O	10	23	−67.9	(**1616**)
$C_7H_{12}O_7$	*d*-Mannoheptonic acid anhydride	H_2O	10.01	20	−74.23	(**1369**)
$C_7H_{12}O_9$	α-Pentahydroxypimelic acid	H_2O	*10*		0	(**461**)
$C_7H_{14}O_7$	Rhamnohexonic acid	H_2O	10.03	20	83.8	(**530**)
$C_7H_{14}O_8$	Mannoheptonic acid	H_2O	*5.27*	20	75.15	(**1971**)
$C_7H_{15}NO_7$	Chondrosaminoheptonic acid	2.5% HCl	2.428	20	−14.4*	(**1221**)
$C_7H_{15}NO_7$	Galaheptosamic acid	5% HCl	*8.76*	20	11.23	(**522**)
$C_7H_{15}O_8$	*d*-Galactoseheptonic acid, barium salt	H_2O	12.01	20	5.50	(**1369**)
	Sugars with 7 carbon atoms and derivatives					
$C_7H_{14}O_6$	Rhamnohexose	H_2O	*9.675*	20	−61.4*	(**530**)
$C_7H_{14}O_7$	α-Glucoheptose	H_2O	10	20	−25*	(**461**)
	β-Glucoheptose	H_2O	5.125	20	−12.2	(**1616**)
$C_7H_{14}O_7$	β-Galaheptose	H_2O	*9.2*	20	−54.4*	(**466**)
$C_7H_{14}O_7$	Mannoheptose	H_2O	*10.807*	20	68.64*	(**529**); *cf.* (**1971**)
$C_7H_{14}O_7$	*d*-Mannoheptose	H_2O	*18.8*	20	29.37	(**1159**)
$C_7H_{14}O_7$	Perseulose	H_2O	10	25	−81	(**129**)
$C_{19}H_{26}O_{13}$	α-Glucoheptose β-hexaacetate	$CHCl_3$		20	4.8	(**951**)
	α-Glucoheptose α-hexaacetate	$CHCl_3$		20	87.0	
$C_{19}H_{26}O_{13}$	Hexaacetyl-*d*-α-mannoheptose (isomer a)	$CHCl_3$	5.59	20	24.4	(**948**)
	(Isomer b)	$CHCl_3$	0.982	20	−31	
	Heptahydric alcohols					
$C_7H_{16}O_7$	β-Glucoheptitol	H_2O			0.80	(**1614**)
		H_2O	10	10	48.0	(**1616**)
		5% Borax	10	10	−50*	

* Mutarotation.

Heptahydric alcohols.—(Continued)

Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{21}H_{30}O_{14}$	Heptaacetyl β-glucoheptitol	EtOH	10	13	34.8	(1616)
	SUGARS, ETC., CONTAINING 8 CARBON ATOMS					
$C_8H_{14}O_8$	Galactooctonic lactone	H_2O	*4.26*	20	64.0	(530)
$C_8H_{14}O_8$	α, α-Glucooctonic lactone	H_2O	10.0	22	47.05*	(1616)
	α, β-Glucooctonic lactone	H_2O	8	17	24.1	
$C_8H_{14}O_8$	α-Glucooctonic acid anhydride	H_2O	*10.405*	20	45.9	(461)
	β-Glucooctonic acid anhydride	H_2O	*11.399*	20	23.6	
$C_8H_{14}O_8$	Mannooctonic acid anhydride	H_2O	*9.85*	20	−43.58	(529)
$C_8H_{16}O_7$	Rhamnoheptose	H_2O	*9.40*	20	8.4	(461)
$C_8H_{16}O_8$	α, α-Glucooctose (α-form)	H_2O	7.25	18	−93 to −50.8	(1616)
		H_2O	*6.496*	20	−50.5	(461)
	α, α-Glucooctose (β-form)	H_2O	1.8		−28	(1616)
$C_8H_{18}O_8$	α, α-Glucooctitol	H_2O	10.0	15	1.9	(1616)
	SUGARS, ETC., CONTAINING 9 CARBON ATOMS					
$C_9H_{16}O_8$	Rhamnooctonic acid anhydride	H_2O	*4.762*	20	−50.8	(530)
$C_9H_{16}O_9$	α-Gluconononic acid anhydride	H_2O	10	20	33	(461)
$C_9H_{16}O_9$	Mannonononic acid anhydride	H_2O	10.00	20	−41.0	(529)
$C_9H_{16}O_9$	α, α, α-Gluconononic lactone	H_2O	10.0		28.7*	(1616)
$C_9H_{18}O_9$	α, α, α-Gluconnonose	H_2O	11.6	15	13.5	(1616)
$C_9H_{20}O_9$	α, α, α-Glucononitol	H_2O	1.5	15	1.5	(1616)
	SUGARS, ETC., CONTAINING 10 CARBON ATOMS					
$C_{10}H_{18}O_{10}.H_2O$	α-Deconic lactone hydrate	H_2O	6.0	20	−41.0*	(1616)
	β-Deconic lactone hydrate	H_2O	5:0	17	−28.0*	
$C_{10}H_{20}O_{10}$	α, α, α-Glucodecose	H_2O	10.0	20	50.4*	(1615, 1616)
$C_{10}H_{22}O_{10}$	α-Glucodecitol	H_2O	2.0	20	1.2	(1615, 1616)
$C_{20}H_{38}O_{21}$	β-Deconic anhydride	H_2O	1.2	13	−20.4*	(1616)
$C_{30}H_{42}O_{20}$	Decaacetyl-α-glucodecitol	$CHCl_3$	5.0	18	16.0	(1615, 1616)
	SUGARS, ETC., CONTAINING 12 CARBON ATOMS					
	Derivatives of saccharose					
$C_{19}H_{36}O_{11}$	Heptamethylsaccharose	MeOH	5.585		68.5	(837)
$C_{20}H_{38}O_{11}$	Octomethylsaccharose	MeOH	5.15	20	51.5	(1735)
		MeOH	7.345		69.3	(837)
		Me_2CO	6.782		66.8	
	Lactal, lactose and derivatives					
$C_{12}H_{20}O_9$	Lactal  $\left(\begin{array}{l}C_6H_{11}O_5.O \quad \overbrace{\qquad\quad O \qquad\quad}\\ HO.CH_2.CH.CH.CHOH.CH:CH\end{array}\right)$	H_2O	*9.38*	16	27.70	(111.5)
	Boiled in H_2O	H_2O			36.43	
		H_2O	*1.01*	22	28.53	(497)
	Calc. as hydrate	H_2O	*1.01*	22	26.95	
		H_2O	*9.93*	19	26.92	
$C_{22}H_{30}Br_2O_{13}$	Dibromo-ψ-lactal pentaacetate	$C_2H_2Cl_4$	*4.25*	23	69.6	(111.5)
$C_{22}H_{40}O_{11}$	*l*-Menthyl-β-lactoside	H_2O	*1.109*	16	−38.11	(482)
		H_2O	*1.251*	16	−37.97	
$C_{24}H_{30}Br_2O_{13}$	Dibromolactal hexaacetate	$C_2H_2Cl_4$	*6.10*	18	135.5	(497)
$C_{24}H_{32}O_{15}$	Lactal hexaacetate	$C_2H_2Cl_4$	*7.54*	19	−12.27	(497)
$C_{24}H_{32}O_{15}$	ψ-Lactal hexaacetate	$C_2H_2Cl_4$	*8.8*	18	32.24	(111.5)
	Isolactal hexaacetate	$C_2H_2Cl_4$	*5.83*	23	55.30	
$C_{26}H_{35}BrO_{17}$	Bromolactose heptaacetate	$CHCl_3$	*3.80*	14	108.17	(388)
$C_{26}H_{36}O_{18}$	Lactose heptaacetate	$CHCl_3$			52.8	(950)
$C_{36}H_{54}O_{18}$	Heptaacetyl-*l*-menthyl-β-lactoside	$C_2H_2Cl_4$	*11.18*	19	−29.66	(482)
	Maltose and derivatives (including amygdalin)					
$C_{14}H_{26}O_{11}$	Ethylmaltoside	H_2O	*7.03*	16.5	79.22	(518)
$C_{18}H_{26}O_{11}$	β-Phenylmaltoside	H_2O	*5.1*	20	34.0	(490)
$C_{19}H_{27}NO_{12}$	Maltose-*o*-carboxyanilide	MeOH	0.919	20	68*	(968)
$C_{19}H_{28}O_{11}$	Benzylmaltoside	H_2O	*4.85*	17	47.64	(518)
$C_{20}H_{27}NO_{11}$	Amygdalin ($C_{12}H_{21}O_{10}.O.CH(CN).C_6H_5$)	H_2O	2.124		−38.0	(2047)
		H_2O	*4*	17	−37.25	(1141)
$C_{24}H_{23}O_{15}$	Maltal hexaacetate	$C_2H_2Cl_4$	*3.38*	16.5	64.2	(518)
$C_{25}H_{38}O_{18}$	Methylmaltoside heptaacetate	$CHCl_3$	6.0	20	53.8	(950)

* Mutarotation.

Maltose and derivatives (including amygdalin).—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{26}H_{35}BrO_{17}$	Bromomaltose heptaacetate	$CHCl_3$	*37.9*	19	171.5	(518)
$C_{26}H_{35}NO_{20}$	Maltose nitrate heptaacetate	$CHCl_3$	*5.27*	19	149.30	(1119)
		$C_2H_2Cl_4$	*6.08*	10	103.0*	(518)
$C_{26}H_{36}O_{18}$	Maltose heptaacetate	$CHCl_3$		20	110*	(950)
		$C_2H_2Cl_4$		20	95.4*	
$C_{28}H_{38}O_{19}$	α-Maltose octaacetate	MeOH	5.06	20	121.25	(946)
		MeOH	10.07	20	120.25	
		$CHCl_3$	5.01	20	122.75	
		$CHCl_3$	9.94	20	121.95	
		C_6H_6	5.00	20	124.05	
		C_6H_6	9.93	20	123.1	
		99.5% Me_2CO	3.95	20	124.3	
		50% Me_2CO	10.12	20	124.25	
$C_{28}H_{38}O_{19}$	β-Maltose octaacetate	$CHCl_3$	5.09	20	62.5	(946)
		$CHCl_3$	10.61	20	62.9	
		C_6H_6	5.20	20	74.85	
		C_6H_6	10.26	20	74.5	
		Me_2CO	5.45	20	54.8	
		Me_2CO	10.43	20	57.4	
$C_{28}H_{38}O_{19}$	Maltose octaacetate	C_6H_6	*2*		76.54	(857); *cf.* (859, 860)
		$CHCl_3$	*2*		61.01	
		EtOH	*1*		60.02	
$C_{28}H_{40}O_{18}$	Ethylmaltoside heptaacetate	$C_2H_2Cl_4$	*3.72*	14	48.93	(518)
$C_{33}H_{42}O_{18}$	Benzylmaltoside heptaacetate	$C_2H_2Cl_4$	*6.92*	16.5	27.7	(518)
$C_{34}H_{41}NO_{18}$	Heptaacetylamygdalin	$CHCl_3$	2.037		−37.6	(2047)
		AcOEt	2.026		−34.0	
	Heptaacetylneoamygdalin	$CHCl_3$	2.211		−65.6	
		AcOEt	2.218		−57.1	
	Cellose, cellobial, cellobiose and derivatives					
$C_{12}H_{20}O_9$	Cellobial	H_2O	*8.744*	20	1	(502)
$C_{12}H_{22}O_9$	Hydrocellobial	H_2O	*9.374*	21	4.1	(502)
$C_{24}H_{32}O_{15}$	Cellobial hexaacetate	$C_2H_2Cl_4$	*6.753*	17	−19.8	(502)
$C_{24}H_{32}Br_2O_{13}$	Cellobial dibromide hexaacetate	$C_2H_2Cl_4$	*6.424*	20	57.9	(502)
		$C_2H_2Cl_4$		20	57.4	
$C_{24}H_{34}O_{15}$	Hydrocellobial hexaacetate	$C_2H_2Cl_4$	*5.912*	19	11.2	(502)
$C_{25}H_{38}O_{18}$	Methylcelloside heptaacetate	$CHCl_3$	4.55	20	−25.4	(950)
$C_{26}H_{35}ClO_{17}$	Chlorocellobiose heptaacetate	$CHCl_3$	*2.75*	20	74.87	(1961)
$C_{26}H_{35}FO_{17}$	Fluorocellobiose heptaacetate	$CHCl_3$	*4.08*	20	30.03	(231)
$C_{26}H_{36}O_{18}$	Cellose heptaacetate	$CHCl_3$			22.6*	(950)
$C_{28}H_{38}O_{19}$	α-Cellose octoacetate	$CHCl_3$	5	20	40.85	(946)
		$CHCl_3$	10	20	41.95	
	β-Cellose octoacetate	$CHCl_3$	5	20	−14.75	
		$CHCl_3$	10	20	−14.5	
$C_{33}H_{40}O_{19}$	β-Benzoylcellobiose heptaacetate	$CHCl_3$	*4.50*	20	−30.5	(2241)
$C_{33}H_{40}O_{20}$	β-Salicylcellobiose heptaacetate	$CHCl_3$	*3.35*	20	−43.43	(2241)
$C_{35}H_{43}NO_{20}$	Hippurylcellobiose heptaacetate	$CHCl_3$	*3.37*	20	−15.04	(2241)
	Gentiobiose and derivatives					
$C_{20}H_{38}O_{11}$	Heptamethylmethylgentiobioside	H_2O			−33.9	(842.5)
		EtOH			−29.9	
		MeOH			−30.0	
		Me_2CO	0.57		−27.0	
$C_{24}H_{32}N_4O_9$	Gentiobiose osazone	40% Py in EtOH	*1.523*	20	−76.1	(2238, 2239)
$C_{28}H_{38}O_{19}$	Gentiobiose octoacetate	$CHCl_3$	*1.723*	20	−5.3	(2238, 2239)
	OTHER DISACCHARIDES AND POLYSACCHARIDES					
$(C_6H_{10}O_5)_n$	Levulomannan	very dil. KOH	2.0		−44.1	(72)
$(C_6H_{10}O_5)_n$	Mannogalactan	H_2O	3.15		74.2	(72)
$C_{10}H_{17}NO_6$	Phaseolunatine	H_2O	7.009	28	−27.7	(743)
$C_{11}H_{20}O_{10}$	Vicianose	H_2O	8	20	39.72*	(135); *cf.* (130)
$C_{12}H_{14}Cl_4O_{11}S_2$	Trehalosetetrachlorohydrine disulfate	$CHCl_3$	*3.21*	17	151.9	(848)
		$CHCl_3$	*2.75*	20	152.3	

* Mutarotation.

OTHER DISACCHARIDES AND POLYSACCHARIDES.—(*Continued*)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{12}H_{20}O_{10}.2H_2O$	Diamylose	H_2O	*0.6375*	24	136.2	(1721)
		50% EtOH	*1.034*	24	136.4	
$C_{12}H_{20}O_{10}$	Isodiamylose	H_2O	3.16	24	168.3	(1719)
$C_{12}H_{22}O_9$	Hydrolactal	H_2O	*9.67*	20	28.38	(497)
$C_{12}H_{22}O_9$	Cyclamose	H_2O			−15.15	(1423); *cf.* 1399)
		HCl dil.			−66.54	
$C_{12}H_{22}O_{11}$	5-Galactosidomannose	H_2O	*1.20*	23	23.04	(111.5)
$C_{12}H_{22}O_{11}$	Galactobioses (A)	H_2O		16	53.05	(187)
		90% EtOH		19	39.3	(182)
		40% EtOH		19	49.0	
	(B)	H_2O			35.0	(188); *cf.* (186)
$C_{12}H_{22}O_{11}$	Melibiose	H_2O	*17.3*	20	143.27	(95)
$C_{12}H_{22}O_{11}$	Verbascose	H_2O	1.324		169.9	(189.5)
$C_{16}H_{20}O_9$	Gentiopicrin	H_2O?	*0.394*		−196.7	(243)
		AcOEt	*6.094*		−196.9	(189); *cf.* (245)
$C_{18}H_{22}N_2O_4$	Apiose phenylhydrazone	H_2O	3.40	20	3.8	(2076)
$C_{18}H_{30}O_{15}.4H_2O$	Triamylose	H_2O	0.9479	24	151.4	(1721)
		H_2O	0.9913	24	151.8	
$C_{18}H_{30}O_{15}$	Isotriamylose	H_2O	2.81	24	172.8	(1719)
$C_{20}H_{38}O_{11}$	Octamethylglucosidoglucoside	MeOH	6.23	20	135.9	(1735)
$C_{21}H_{24}O_9$	Rhapontin	50% Me_2CO	2	15	−63.0	(897)
$C_{24}H_{32}N_4O_9$	Galactoarabinose benzylphenylhydrazone	50% EtOH	1.67		−23.7	(1808)
$C_{24}H_{32}O_{16}$	Diamylose hexaacetate	AcOH	*5.969*	24	100.6	(1721)
		AcOH	2.03	20	101.6	(1719)
$C_{24}H_{32}O_{16}$	Isodiamylose hexaacetate	AcOH	2.44	24	128.9	(1719)
$C_{24}H_{40}O_{20}.2EtOH$	α-Dextrin (tetraamylose)	H_2O	*0.8549*	24	138.6	(1721)
$C_{24}H_{42}O_{15}$	Hexamethyltriamylose	EtOH	2.12	20	138.1	(1720)
$C_{24}H_{42}O_{21}.H_2O$	Lupeose	H_2O	*5*	22	138	(1910, 1984)
$C_{24}H_{42}O_{21}$	Manneotetrose	H_2O	10		150	(2002)
$C_{25}H_{28}O_{12}$	Dibenzoylglucoxylose	MeOH	1.05		−105.9	(2050)
	Isodibenzoylglucoxylose	MeOH	1.05		−6.3	
$C_{31}H_{34}O_{14}$	Pentaacetylrhapontin	AcOH	2	15	−11.6	(897)
$C_{36}H_{48}O_{24}$	Triamylose nonoacetate	AcOH	*2.966*	24	112.4	(1721)
$C_{36}H_{48}O_{24}$	Isotriamylose nonoacetate	AcOH	2.38	24	130.1	(1719)
$C_{36}H_{60}O_{30}.9H_2O$	β-Dextrin (hexaamylose)	H_2O	*1.087*	24	158.3	(1721)
$C_{36}H_{64}O_{32}$	Stachyose	H_2O	9		148.1	(98, 1484, 2245)
$C_{37}H_{36}O_{20}$	Scrotin octaacetate	$CHCl_3$	1.003		−76.4	(1698)
$C_{48}H_{84}O_{30}$	Dodecamethyl-β-hexaamylose	EtOH	*4.13*	20	142.9	(1720)
	Dodecamethyl-α-hexaamylose	EtOH	*2.08*	20	148.73	

IC₁. The Molecule Contains One Asymmetric Atom Attached to Three Other Carbon Atoms

HYDROCARBONS AND THEIR HALOGEN DERIVATIVES

$C_5H_{11}Br$	*d*-Amyl bromide $(CH_3.CH_2.CH(CH_3).CH_2Br)$		1.221	20	3.68	(1377)
$C_5H_{11}I$	*d*-Amyl iodide $(CH_3.CH_2.CH(CH_3).CH_2I)$		1.524	20	5.64	(1377)
			1.5232	15	5.78	(1091)
$C_6H_{13}Br$	γ-Methyl-*n*-amyl bromide $(CH_3.CH_2.CH(CH_3).CH_2.CH_2.Br)$		1.1852^{19}	19	19.97	(827)
	And at intermediate temperatures		1.0319^{142}	142	13.97	
C_7H_{16}	*d*-Methylethylpropylmethane		0.6865	20	9.5	(1377)
$C_{12}H_{16}$	α-Phenyl-γ-methyl-Δ^{α}-pentene $(C_6H_5.CH:CH.CH(CH_3).CH_2.CH_3)$		0.8906	15	50.3	(1091)
$C_{12}H_{18}$	α-Phenyl-γ-methylpentane $(C_6H_5.CH_2.CH_2.CH(CH_3).CH_2.CH_3)$		0.8644	14.5	17.20	(1091)
			0.7396	168	13.66	(827)
$C_{12}H_{16}Br_2$	α-Phenyl-α, β-dibromo-γ-methylpentane $(C_6H_5.CHBr.CHBr.CH(CH_3).CH_2.CH_3)$	$CHCl_3$	0.127	15	32.1	(1091)
$C_{15}H_{22}$	Δ^{α}-γ-Methylpentenyl-*p*-isopropylbenzene $(C_3H_7.C_6H_4.CH:CH.CH(CH_3).CH_2.CH_3)$		0.8801_4^{16}	16	41.89	(1092)
$C_{15}H_{24}$	γ-Methylpentanyl-*p*-isopropylbenzene $(C_3H_7.C_6H_4.CH_2.CH_2.CH(CH_3).CH_2.CH_3)$		$0.8632_4^{15.5}$	15.5	15.91	(1092)

HYDROCARBONS AND THEIR HALOGEN DERIVATIVES.—(*Continued*)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{16}H_{24}$	γ, η-Dimethyl-Δ^η-octenylbenzene ($C_6H_5.CH_2.CH_2.CH(CH_3).CH_2.CH_2.CH_2.$-$C(CH_3):CH_2$)		$0.8844_4^{11.5}$	11.5	−7.26	(1093)
$C_{16}H_{26}$	γ, η-Dimethyloctylbenzene ($C_6H_5.CH_2.CH_2.CH(CH_3).CH_2.CH_2.CH_2.$-$CH(CH_3)_2$)		$0.8789_4^{10.5}$	10.5	−1.82	(1093)
$C_{17}H_{24}$	2, 6-Dimethyl-Δ²-nonadiene-9-benzene ($C_6H_5.CH:CH.CH_2.CH(CH_3).CH_2.CH_2.$-$CH:C(CH_3)_2$)		0.8894	20	−3.33	(1814)
	ALCOHOLS AND THEIR DERIVATIVES					
	Amyl alcohol and derivatives, homologues and esters					
$C_6H_{14}O$	γ-Methyl-*n*-amyl alcohol ($CH_3.CH_2.CH(CH_3).CH_2.CH_2OH$)		$0.8262^{20.5}$	20.5	8.77	(827)
	And at intermediate temperatures		0.7276^{147}	147	6.10	
$C_8H_{14}O_2$	*d*-Amyl pyruvate			13	4.7	(1344.5)
$C_{12}H_{16}O_5$	*d*-Amyl gallate			17	4.0	(1344.5)
$C_{12}H_{17}NO_2$	*d*-Amyl phenylcarbamate	$CHCl_3$	5		6.4	(1377)
$C_{13}H_{15}NO_2$	*d*-Amylphthalimide		1.0930	25	7.53	(1377)
$C_{13}H_{15}NO_6$	α-*l*-Amyl β-hydrogen γ-nitrophthalate	Me_2CO	10	17	6.5	(1379)
$C_{13}H_{15}NO_6$	β-*d*-Amyl hydrogen γ-nitrophthalate	Me_2CO	10		2.6	(1376)
$C_{13}H_{16}O_3$	*d*-Amyl benzoylformate			19	4.1	(1344.5)
$C_{22}H_{24}O_2$	Amyl α-phenylcinnamenylacrylate	EtOH	*9.97*	20	3.87	(1821)
$C_{22}H_{26}O_2$	Amyl α, δ-diphenyl-Δ^{2,3}-pentenoate	EtOH	*9.99*	20	7.15	(1821)
	Amyl α, δ-diphenyl-Δ^{1,2}-pentenoate	EtOH	*9.98*	20	4.84	
	Linalool and citronellol					
$C_{10}H_{18}O$	*l*-Linalool; *cf.* (79, 80, 1461) ($(CH_3)_2C:CH.CH_2.CH_2.$-$C(CH_3)OH.CH:CH_2$)		0.8622^{20}		−19.62	(2025)
$C_{10}H_{20}O$	*d*-Citronellol; *cf.* (80, 82.5, 125.05, 170, 407, 1385, 1444, 2030) ($(CH_3)_2C:CH.CH_2.CH_2.$-$CH(CH_3).CH_2.CH_2OH$)		0.8618_{15}^{15}		2.65	(1871.5)
			0.8565	17.5	4.0	(2029)
$C_{10}H_{22}O$	Tetrahydro-*l*-linalool ($(CH_3)_2C(CH_2)_3.C(CH_3)(OH).CH_2.CH_3$)		0.836_{17}^{17}	17	−24	(85)
$C_{12}H_{24}O$	Ethyl-α-citronellol				−11.26	(67)
$C_{12}H_{24}O$	Dimethyl-α, α-citronellol				−11.38	(67)
$C_{12}H_{24}O_2$	Tetrahydrolinaloyl acetate		0.891_0^4	17	−2.2	(85)
$C_{13}H_{22}O$	Linaloyl allyl ether ($C_{10}H_{17}.O.C_3H_5$)		$0.8665_4^{16.4}$		2.0	(814)
$C_{14}H_{28}O$	Diethyl-α, α-citronellol				−13.25	(67)
	Other alcohols and derivatives					
$C_{10}H_{20}O_3$	γ, δ-Dimethoxy-β-Σ-dimethylhexane-β-Σ-diol anhydride	Me_2CO	4.495	20	13.35	(1747)
$C_{11}H_{22}O$	β, δ-Dimethyl-Δ′-nonenol		0.8578	20	0.55	(1839)
$C_{14}H_{14}O$	*d*-α-Phenyl-α′-*p*-hydroxyphenylethane ($C_6H_5.CH(CH_3).C_6H_4OH$)	$CHCl_3$	5.58		6.54	(1627)
		C_6H_6	4.95		7.78	
$C_{14}H_{20}O$	α-*p*-Ethoxyphenyl-γ-methyl-Δ^α-pentene ($C_2H_5O.C_6H_4.CH:CH.CH(CH_3).CH_2.CH_3$)		0.9406	15	40.97	(1092)
$C_{14}H_{22}O$	α-*p*-Ethoxyphenyl-γ-methylpentane ($C_2H_5O.C_6H_4.CH_2.CH_2.CH(CH_3).CH_2.CH_3$)		0.9119	16	14.99	(1092)
$C_{25}H_{33}NO_3$	*d*-α-Phenyl-α′-*p*-hydroxyphenylethane-*l*-menthylcarbamate	$CHCl_3$	5.03		−41.8	(1627)
	AMINES AND HYDRAZINES					
$C_5H_{13}N$	*d*-Amylamine ($CH_3.CH_2.CH(CH_3).CH_2.NH_2$)		0.7505	25	−5.86	(1377); *cf.* (828)
$C_{12}H_{19}N$	Methyl-*l*-amylaniline ($CH_3.CH_2.CH(CH_3).CH_2.N(CH_3).C_6H_5$)		0.9220	15	11.06	(1007)
$C_{11}H_{18}N_2$	*d*-Phenylamylhydrazine ($CH_3.CH_2.CH(CH_3).CH_2.N(NH_2).C_6H_5$)		0.9521	room	4.75*	(1503)
	KETONES AND ALDEHYDES AND THEIR CONDENSATION PRODUCTS					
$C_5H_{10}O$	*d*-Valeraldehyde ($CH_3.CH_2.CH(CH_3).CHO$)		0.8068	20	23.56	(410)
$C_{10}H_{18}O$	Citronellal ($(CH_3)_2C:CH.CH_2.CH_2.CH$-$(CH_3).CH_2.CHO$)		0.8538	17.5	12.50	(2029)
			0.8509	25	4.8	(389, 390)

* Increasing with time.

KETONES AND ALDEHYDES AND THEIR CONDENSATION PRODUCTS.—*(Continued)*

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{11}H_{20}O$	β, ξ-Dimethyl-Δ^α-nonene-θ-one $(CH_3.CO.CH_2.CH(CH_3).(CH_2)_3.C(CH_3):CH_2)$		0.8650	20	5.89	(1839)
$C_{13}H_{22}O$	Citronellideneacetone $((CH_3)_2C:CH.CH_2.CH_2.CH(CH_3).CH_2.CH:CH.CO.CH_3)$		0.8737	20	−2.70	(1836)
$C_{12}H_{20}O_2$	Citronellideneacetic acid		0.9326	20	−6.49	(1836)
$C_{13}H_{22}O_2$	Methyl citronellideneacetate	EtOH	*9.718*	20	−9.56	(1836)
	ACIDS AND DERIVATIVES					
	Isovaleric acid and its homologues					
$C_5H_{10}O_2$	Isovaleric acid (*d*-methylethylacetic acid, $CH_3.CH_2.CH(CH_3).COOH$)		0.9471	16.5	17.95	(1700)
				24	18.2	(1706)
$C_6H_{11}BrO_2$	*d*-α-Bromo-β-methylvaleric acid	C_6H_6	*9.99*	20	26.48	(13)
$C_9H_{15}NO_2$	*d*-Cyanoisopropylvaleric acid	PhMe	*9.85*	20	11.4	(500)
$C_9H_{18}O_2$	*d*-Propylisobutylacetic acid $(C_3H_7)CH.C_4H_9(COOH)$			22	9.80	(515)
				24.5	5.73	(515)
$C_{10}H_{20}O_2$	*d*-Butylisobutylacetic acid $(C_4H_9.C(C_4H_9)_2.COOH)$	$C_6H_4Me_2$	14.2	20	6.34	
		EtOH	13.7	20	5.98	
		N NaOH	10.1	20	7.13	
$C_{10}H_{20}O_2$	Tetramethylcaproic acid	EtOH	2.53	17	45.9	(808)
$C_{10}H_{21}NO$	Tetramethylcaproic amide	EtOH	4.77	20	46.6	(808)
$C_{16}H_{33}NO$	α, α-Dipropyl-β, γ-dimethylcaprylic amide	EtOH		18	18.32	(809)
	Aromatic acids					
$C_9H_9ClO_2$	*d*-α-Chloro-α-phenylpropionic acid	C_6H_6	1.690	20	26.0	(1334)
$C_9H_9ClO_2$	*l*-α-Phenyl-α-chloropropionic acid	C_6H_6	7.188		−26.3	(1335)
$C_9H_{10}O_2$	α-Phenylpropionic acid $(C_6H_5.CH(CH_3).COOH)$	EtOH	3.159	20	57.94	(1767)
		$CHCl_3$	2.834	20	76.2	
$C_{10}H_{11}ClO$	*d*-Benzylmethylacetyl chloride	Et_2O	18.0		18	(1079)
					22.65	(1636)
$C_{10}H_{12}O_2$	*d*-Benzylmethylacetic acid	$CHCl_3$	3.282		27.7	
		C_6H_6	3.732		27.1	
	Sodium salt	H_2O	2.226		35.9	(1636)
		H_2O	2		26	(1079)
$C_{11}H_{12}O_2$	*d*-Phenylallylacetic acid	$CHCl_3$	2.147		84.6	(1636)
		C_6H_6	2.44		103.2	
	Sodium salt	H_2O	1.676		20.3	(1636)
$C_{11}H_{14}O_2$	*d*-Benzylethylacetic acid	$CHCl_3$	2.489		38.4	(1636)
		C_6H_6	2.464		41.0	
	Sodium salt	H_2O	1.905		50.4	(1636)
$C_{11}H_{14}O_2$	*d*-Phenylpropylacetic acid	C_6H_6	2.935		72.10	(1636)
		C_6H_6	2.935		79.1	
		$CHCl_3$	4.047		58.8	
	Sodium salt	H_2O	1.599		140.7	(1636)
$C_{15}H_{14}O_2$	*d*-α-Phenylhydrocinnamic acid $(C_6H_5.CH_2.CH(C_6H_5).COOH)$	C_6H_6	10.1	20	94.04	(1834)
$C_{16}H_{14}O_3$	*l*-β-Benzoyl-α-phenylpropionic acid $(C_6H_5.CO.CH_2.CH(C_6H_5).COOH)$	AcOEt	1.67		157.3	(825.5)
$C_{18}H_{21}NO$	*d*-Benzylmethylacet-*l*-phenylethylamide	Et_2O	2.15		8.6	(1081)
$C_{19}H_{21}NO$	*d*-Benzylmethylacet-*d*-hydrindamide	MeOH	4.30		−15.5	(1081)
$C_{20}H_{23}NO$	*d*-Benzylmethylacet-*l*-methylhydrindamide	$CHCl_3$	2.04		−26.5	(1081)
$C_{25}H_{32}O_2$	*l*-Menthyl *d*-α-phenylhydrocinnamate	C_6H_6	10.02	20	−89.06	(1834)
	l-Menthyl *l*-α-phenylhydrocinnamate	C_6H_6	9.97	20	−21.97	
	Hydroxy acids					
$C_4H_7BrO_3$	*d*-β-Bromo-α-methyllactic acid $(CH_2Br.C(CH_3)(OH).COOH)$	H_2O	*9.68*	20	7.4	(1047)
$C_4H_7O_4K$	*d*-α-Methylglycerate $(HO.CH_2.CH(CH_2OH).COOH)$	H_2O	*9.85*	20	−4.00	(1047)
$C_9H_{10}O_3$	*d*-α-Phenyl-α-hydroxypropionic acid $(C_6H_5.C(CH_3)(OH).COOH)$	EtOH	3.354	13.8	37.7	(1334)
		Me_2CO	4.142	13	−36.5	
		H_2O	2.160	14.5	−51.1	
		H_2O	1.589	13	−52.5	
		H_2O	0.688	14.5	−53.8	

Hydroxy acids.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_9H_{10}O_3$	*d*-Tropic acid ($C_6H_5.CH.(CH_2OH).COOH$)	EtOH	2.69	16	72.2	(1351)
		H_2O	1.52	16	80.2	
		Me_2CO	2.19	13	83.8	
$C_9H_{16}O_2$	*l*-δ-Hydroxy-α-isopropyl-*n*-hexoic acid	EtOH	2.092		−13.54	(2045)
$C_{10}H_{12}O_3$	*p*-Methoxyhydratropic acid ($CH_3O.C_6H_4.CH(CH_3).COOH$)	EtOH			−67.67	(179)
$C_{11}H_{14}O_3$	Ethyl atrolactate (*l*-ethyl α-hydroxy-α-phenylpropionate)		1.097	13	−26.7	(1335)
$C_{19}H_{28}O_3$	*l*-Menthyl *l*-atrolactate	Me_2CO	1.98	9.5	−74.7	(1357)
		EtOH	1.27	10	−90.3	
		$CHCl_3$	1.42	14	−102.7	
$C_{19}H_{28}O_3$	*l*-Menthyl *dl*-atrolactate	CS_2	2.41	9	−55.9	(1357)
		C_6H_6	2.12	15	−63.8	
		Me_2CO	2.04	14	−66.2	
		$CHCl_3$	2.01	11	−69.5	
		EtOH	2.40	15	−72.0	
	IC_1 and ICB. Amino acids					
$C_5H_{11}NO_2$	*d*-α-Aminoethylmethylacetic acid ($CH_3.CH_2.C(CH_3)(NH_2).COOH$)	H_2O	*8.52*	20	11.0	(506)
		20% HCl	*10*	21	7.26	
$C_6H_{13}NO_2$	*d*-Isoleucine* (*d*-α-amino-β-methylvaleric acid)	H_2O	*3.08*	20	11.29	(1265)
		20% HCl	*4.64*	20	40.61	
		H_2O	*3.87*	20	9.74	(409.5)
		20% HCl	*4.57*	20	36.80	
		N NaOH	*3.28*	20	11.09	
$C_6H_{13}NO_2$	Alloisoleucine	H_2O	2.39	20	−14.4	(410)
		20% HCl	*4.70*	20	−36.95	
	α-Alloisoleucine	20% HCl	*4.71*	20	−35.7	(412)
$C_7H_{13}NO_3$	*d*-α-Formylamino-β-methylvaleric acid	EtOH	*9.04*	20	28.26	(1265)
$C_8H_{14}ClNO_3$	Chloroacetyl-*d*-isoleucine	EtOH	*4.88*	20	25.0	(13)
$C_9H_{11}NO_2$	*d*-α-Amino-α-phenylpropionic acid	H_2O	2.02	18	70.0	(1336)
		N HCl	3.946	18	90.1	
	l-α-Amino-α-phenylpropionic acid	H_2O	1.82	20	−69.5	
		N HCl	2.74	18	−90.3	
$C_9H_{16}BrNO_3$	*d*-α-Bromopropionyl-*d*-isoleucine	EtOH	*4.8*	20	24.5	(13)
$C_{10}H_{11}NO_3$	*d*-α-Formylamino-α-phenylpropionic acid	0.24*N* NaOH	4.626	15	130.1	(1336)
		EtOH	3.214	16	91.9	
$C_{12}H_{17}NO_4S$	Benzenesulfono-*d*-isoleucine	0.33*N* NaOH	*7.37*	20	−11.63	(1265); *cf.* (409, 409.5)
		N NaOH	7.62	20	−12.04	
$C_{12}H_{22}BrNO_3$	*d*-α-Bromoisohexoyl-*d*-isoleucine	AcOEt	*4.57*	20	48.97	(13)
$C_{13}H_{17}NO_3$	Benzoyl-*d*-isoleucine	*N* NaOH	*7.43*	20	26.36	(409.5)
$C_{13}H_{17}NO_3$	Benzoyl-*d*-α-amino-β-methylvaleric acid	0.5*N* NaOH	*7.04*	20	−26.03	(1265)
$C_{13}H_{18}N_2O_3$	*d*-Isoleucine phenylisocyanate	*N* NaOH	*6.0*	20	14.92	(409.5); *cf.* (409)
	IC_1 to IC_n. Dicarboxylic and tricarboxylic acids					
$C_6H_{10}O_4$	Dimethylsuccinic acid†		5		−8	(2169.2)
$C_7H_{12}O_4$	*d*-Trimethylsuccinic acid	H_2O	*5.016*		4.83	(1554.5)
$C_7H_{10}O_4$	Pilopic acid‡	H_2O	3.324	15	36.1	(1015.5)
	Sodium salt	Alk.	9.5	17	3.2	(1015.5)
$C_7H_{12}O_4$	Dimethylglutaric acid	H_2O	10		39.8	(1442)
$C_8H_{12}O_4$	Homopilopic acid§	H_2O	3.524	21	45.4	(1015.5)
	Sodium salt	H_2O	2.82	21	5.9	(1015.5)
$C_8H_{14}O_4$	*d*-α, α′-Dimethyladipic acid	EtOH	*10*	28	31.3	(1523)
$C_8H_{14}O_4$	α, γ-Dimethyladipic acid	EtOH	2.11		4.73	(811)
$C_9H_{16}O_4$	Dimethyl β-methyladipate		1.008	18	−3.82	(811)
$C_9H_{16}O_4$	α-Methyl-γ-ethyladipic acid	EtOH	*1.36*		13.52	(811)
$C_{10}H_{16}O_4$	α-Methyl-γ-allyladipic acid	EtOH	1.97		27.88	(811)
$C_{10}H_{18}O_4$	α-Methyl-γ-propyladipic acid	EtOH	1.96		16.97	(811)

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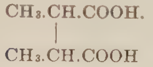
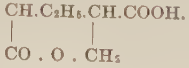
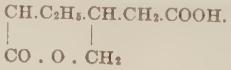
* For polypeptides containing isoleucine, *see* p. 378.

† 
$\begin{array}{l} CH_3.CH.COOH. \\ \quad | \\ CH_3.CH.COOH \end{array}$

‡ 
$\begin{array}{l} CH.C_2H_5.CH.COOH. \\ | \qquad\quad | \\ CO\ .\ O\ .\ CH_2 \end{array}$

§ 
$\begin{array}{l} CH.C_2H_5.CH.CH_2.COOH. \\ | \qquad\quad | \\ CO\ .\ O\ .\ CH_2 \end{array}$

IC_1 to IC_n. Dicarboxylic and tricarboxylic acids.—(Continued)

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_{10}H_{18}O_6$	*d*-α, δ-Dihydroxy-α-methyl-γ-isopropyladipic acid, sodium salt	H_2O	19		5.23	(850)
	d-α, δ-Dihydroxy-α-methyl-γ-isopropyladipic (*p*-acid), sodium salt	H_2O	17.5		4.25	(850)
$C_{11}H_{20}O_4$	Diethyl β-methyladipate		1.04	18	2.40	(811)
$C_{13}H_{24}O_4$	Dipropyl β-methyladipate		0.964	20	2.17	(811)
$C_{15}H_{28}O_4$	Diisobutyl β-methyladipate		0.947	18	2.15	(811)
$C_{16}H_{14}O_4$	*l*-Diphenylsuccinic acid	EtOH	2.33	13	−368.9	(2215)
$C_{16}H_{14}O_4$	*d*-Diphenylsuccinic acid	EtOH	1.07	15	348	(1338)
$C_{22}H_{38}O_7$	Agaric acid, potassium salt	H_2O	*9.84*	18	−9.82*	(2017)
	Sodium salt	H_2O	*12.4*	19	−8.84*	(2017)

ID. The Molecule Contains One Asymmetric Atom Attached to Four Other Carbon Atoms

ACIDS AND DERIVATIVES

Derivatives of acetic, malonic and camphoronic acids

$C_8H_{15}NO_3$	*d*-Ethylisopropylmalonamic acid ($NH_2.CO.C(C_2H_5)(C_3H_7).COOH$)	EtOH	*10.1*	21	14.55	(541)
$C_9H_{10}BrClO_4$	α-Anhydrobromocamphoronyl chloride	$CHCl_3$		20	−6.29	(727)
		H_2O	*13.6*	16	18.22	
		AcOH	*9.12*	16	7.97	
$C_9H_{11}ClO_4$	α-Anhydrocamphoronyl chloride	$CHCl_3$		20	6.25	(727)
	β-Anhydrocamphoronyl chloride	$CHCl_3$		20	−4.21	
$C_9H_{12}O_5$	Anhydrocamphoronic acid	$CHCl_3$			5.56	(727)
$C_9H_{13}NO_2$	*d*-Allylpropylcyanoacetic acid	*N* NaOH	*8.91*	16	16.74	(493)
$C_9H_{13}NO_4$	α-Anhydrocamphoronylimide	EtOH		20	−6.86	(727)
$C_9H_{14}N_2O_3$	α-Camphoronamideimide†	MeOH		28	11.87‡	(727)
	β-Camphoronimideamide	Me_2CO		28	−13.73‡	(727)
$C_9H_{14}O_6$	Camphoronic acid ($HOOC.C(CH_3)_2.C(CH_3)(COOH).CH_2.COOH$)	H_2O	*10*	19.5	−23.91	(58)
$C_9H_{16}O_4$	Methyl hydrogen *d*-ethylisopropylmalonate	EtOH	*9.96*	22	1.84	(541)
		N KOH	*14.1*	23	−3.41	
$C_9H_{17}NO_3$	Methyl *d*-ethylisopropylmalonamate	EtOH	*9.87*	20	−1.97	(541)
		EtOH	*10.47*	22	−2.02	
$C_{11}H_{18}O_6$	Monoethyl dihydrogen camphoronate	EtOH		20	−30.21	(727)
$C_{13}H_{22}O_6$	Diethyl camphoronate	EtOH		20	−9.91	(727)

Class II. ORGANIC SUBSTANCES, AT LEAST ONE ASYMMETRIC CARBON ATOM OF WHICH FORMS PART OF A RING

IIB_1 to B_n. The Molecule Contains Asymmetric Atoms Which Are Attached to Two Other Carbon Atoms

OXYGEN COMPOUNDS

MONOHYDRIC ALCOHOLS

$C_{10}H_{12}O$, ac-Tetrahydro-2-naphthol and derivatives

$C_{12}H_{14}O_2$	*l*-*ac*-Tetrahydro-β-naphthyl acetate		1.0891	20	−57.5	(1621)
				160	−53.2	
$C_{13}H_{16}O_2$	*l*-*ac*-Tetrahydro-β-naphthyl propionate		1.0640	20	−57.0	(1621)
				160	−51.3	
$C_{15}H_{20}O_2$	*d*-*ac*-Tetrahydro-β-naphthyl *n*-valerate		1.0281	20	49.0	(1621)
				160	42.5	
$C_{17}H_{17}NO_2$	*l*-*ac*-Tetrahydro-β-naphthyl phenylcarbamate ($C_{10}H_{11}O.CO.NH.C_6H_5$)	$CHCl_3$	5.340		−26.31	(1621)
		C_6H_6	5.067		−32.95	
$C_{17}H_{24}O_2$	*l*-*ac*-Tetrahydro-β-naphthyl *n*-heptoate		1.0034	20	−42.9	(1621)
				160	−36.9	
$C_{19}H_{28}O_2$	*d*-*ac*-Tetrahydro-β-naphthyl *n*-nonoate		0.9805	20	35.4	(1621)
				160	31.1	
$C_{22}H_{34}O_2$	*d*-*ac*-Tetrahydro-β-naphthyl laurate		0.9645	20	32.7	(1621)
				160	28.1	

POLYHYDRIC ALCOHOLS

Quercitol and derivatives

$C_6H_{12}O_5$	*l*-Quercitol§		4.04		−73.9	(1713)
$C_7H_{14}O_6$	Pinitol ($CH_3.O.C_6H_6(OH)_5$)	H_2O	0.7	20	65.3	(747)
$C_7H_{14}O_6$	*l*-Methylinositol ($CH_3.O.C_6H_6(OH)_5$)	H_2O	*10*		−80	(1637)
$C_{16}H_{22}O_{10}$	Pentaacetyl-*l*-quercitol	$CHCl_3$	2.70		−26.0	(1713)
$C_{17}H_{24}O_{11}$	Pentaacetylpinitol			20	−9.67	(747)
$C_{41}H_{32}O_{10}$	Pentabenzoyl-*l*-quercitol	$CHCl_3$	2.83		−79.0	(1713)

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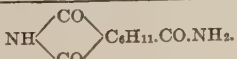
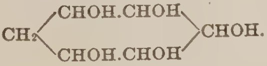
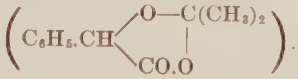
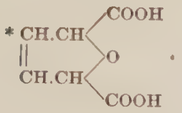
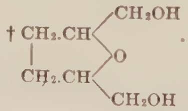
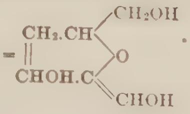
* Calculated on weight of acid. †  $NH\left<\begin{matrix}CO\\CO\end{matrix}\right>C_6H_{11}.CO.NH_2$. ‡ $[\alpha]_{5461}$. §  $CH_2\left<\begin{matrix}CHOH.CHOH\\CHOH.CHOH\end{matrix}\right>CHOH$.

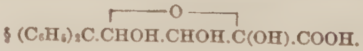
DERIVATIVES OF FURANE

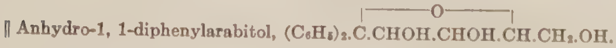
Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_6H_6O_5$	*d*-β-Dihydrofurane-2, 5-dicarboxylic acid*	H_2O	10.15		480.7	(911)
		H_2O	2.5		489.2	
		H_2O	0.157		519	
$C_6H_{12}O_3$	Hydroglucal†	EtOH	*9.913*	20	16.31	(483)
$C_{12}H_{16}O_7$	Triacetylglucal‡	EtOH	*10.43*	22	−15.76	(483)
$C_{12}H_{18}O_7$	Triacetylhydroglucal	EtOH	*9.645*	17	33.93	(483)
		EtOH	*9.352*	17	35.55	
$C_{17}H_{16}O_6$	1, 1-Diphenyl-2, 3, 4-trihydroxytetrahydrofurane-4-carboxylic acid§	EtOH	*1.1869*	14	199.5	(1550)
		EtOH	*1.345*	17	201.7	(1550)
$C_{17}H_{18}O_4$	1, 1-Diphenyl-2, 3-dihydroxy-4-hydroxymethyltetrahydrofurane‖	H_2O	*0.4075*	20	85.6	(1550)
$C_{30}H_{28}O_3$	3, 4-Dimethoxy-2, 2, 5, 5-tetraphenyltetrahydrofurane¶	C_6H_6	8.272	20	−115.7	(1747)
	CARBOXYLIC ACIDS					
	Di- and tetrahydronaphthoic acids					
$C_{11}H_{10}O_2$	$\Delta^{2(3)}$-Dihydro-1-naphthoic acid	$CHCl_3$	1.65		212.9	(1632)
		C_6H_6	23.94		178.0	
	Sodium salt	H_2O	1.390		191.1	(1632)
$C_{11}H_{10}O_2$	Δ^3-Dihydro-2-naphthoic acid	$CHCl_3$	1.802		158.7	(1636)
		C_6H_6	1.597		182.2	
	Sodium salt	H_2O	1.624		157.6	(1636)
$C_{11}H_{12}O_2$	1, 2, 3, 4-Tetrahydro-1-naphthoic acid	$CHCl_3$	1.630		−15.9	(1633)
		C_6H_6	1.750		−52.3	
	Sodium salt	H_2O			−10.6	
$C_{11}H_{12}O_2$	1, 2, 3, 4-Tetrahydro-2-naphthoic acid	$CHCl_3$	1.399		−51.8	(1634)
		C_6H_6	1.382		−50.0	
	Sodium salt	H_2O	1.373		−41.88	(1634)
	Other carboxylic acids					
$C_{11}H_{12}O_3$	Acetone-*l*-mandelic acid 	AcOEt	4.30	18	−94.78	(2187)
	AMINES					
	MONOBASIC AMINES: NITROGEN IN SIDE CHAIN					
	Tetrahydronaphthylamine and derivatives					
$C_{10}H_{14}ClN$	*d-ac*-Tetrahydro-β-naphthylamine hydrochloride	H_2O	1.45	12	71.9	(1667)
$C_{12}H_{15}NO$	Acetyl-*d-ac*-tetrahydro-β-naphthylamine	C_6H_6	0.447	16.5	36.9	(1667)
$C_{17}H_{17}N$	Benzylidene-*d-ac*-tetrahydro-β-naphthylamine	EtOH	1.46	18.5	27.6	(1667)
$C_{17}N_{17}NO$	Benzoyl-*d-ac*-tetrahydro-β-naphthylamine	Me_2CO	0.095	19	58	(1667)
$C_{17}H_{17}NO_2$	*l-ac*-Tetrahydro-2-naphthyl phenylcarbamate	C_6H_6	5.067		−32.95	(1621)
		$CHCl_3$	5.340		−26.31	
	Other monobasic amines					
$C_{10}H_{13}N_3O_2$	*l*-1-Hydroxy-2-semicarbazinohydrindene**	EtOH	0.510	20	−14.7††	(1592)
$C_{11}H_{14}N_2O_5$	*l*-1-Hydroxy-2-hydrazinohydrindeneoxalate‡‡	H_2O	0.375	20	14.0	(1592)
$C_{11}H_{16}ClN$	Pheno-α-aminocycloheptane hydrochloride§§	H_2O	1.09		−24	(1078)
$C_{12}H_{18}IN$	*d*-*N*-Trimethylhydrindonium iodide‖‖	H_2O	1.58		22.2	(1071)
	MONOBASIC AMINES: NITROGEN IN RING					
	Derivatives of piperidine including coniine					
$C_6H_{13}N$	*d*-2-Methylpiperidine (2-pipecoline)		0.860	0	37.29	(1153)

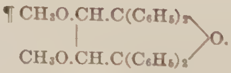


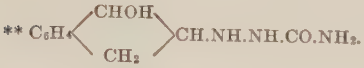


‡ Glucal = 

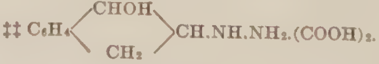

§ $(C_6H_5)_2C.CHOH.CHOH.C(OH).COOH.$

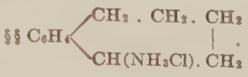

‖ Anhydro-1, 1-diphenylarabitol, $(C_6H_5)_2.C.CHOH.CHOH.CH.CH_2.OH.$

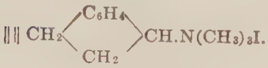




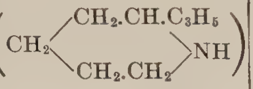
††$[\alpha]_{5461}$.



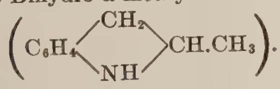
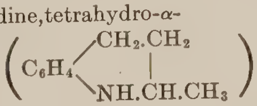




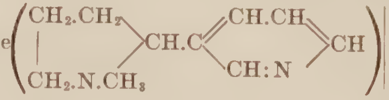
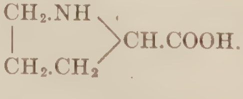
Derivatives of piperidine (including coniine).—(Continued)

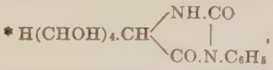
Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_7H_{15}N$	*d*-2-Ethylpiperidine		0.8680^{4}_{4}		17.08	(665)
$C_8H_{15}N$	Iso-2-allylpiperidine  $\left(CH_2\begin{matrix}CH_2.CH.C_3H_5\\CH_2.CH_2\end{matrix}NH\right)$		0.8670^{15}_{4}	15	−29.02	(1269)
$C_8H_{17}N$	*d*-*N*-Ethyl-2-pipecoline		0.8361^{18}		101.06	(914.8)
	l-*N*-Ethyl-2-pipecoline		0.8364^{18}		−98.3	(1887)
$C_8H_{17}N$	*d*-3-Methylpiperidine				3.98	
$C_8H_{17}N$	*d*-*N*-Ethyl-3-pipecoline		0.8095^{17}		−3.2	(1887)
$C_8H_{17}N$	*d*- and *l*-β-Propylpiperidine		0.8517	16	±6.39	(746)
$C_8H_{17}N$	Coniine; *cf.* (1147, 1151, 2207, 2228)		0.873	15	15.6	(1869)
	Coniine	$CHCl_3$	4	27	8.00	(901)
		$CHCl_3$	1	27	9.00	
	Isoconiine (synthetic coniine)		0.8458	18.5	17.85	(1155)
$C_8H_{17}NO$	Conhydrine (β-hydroxyconiine)	EtOH	*10*		10	(1893)
$C_8H_{18}N_2$	Aminoconiine		0.9942^{15}_{15}		−2.33	(1268)
$C_9H_{19}N$	*N*-Methylconiine		0.8318^{24}		81.33	(2207)
		EtOH	*13.6*	24	35.66	(228)
$C_9H_{19}N$	*d*-*N*-Propyl-2-pipecoline		0.8296^{20}		100.34	(914.8)
$C_{10}H_{19}NO$	Acetylconiine		0.9616	16	34.2	(1149)
$C_{10}H_{21}N$	*N*-Ethylconiine		0.8398^{21}		75.62	(915)
$C_{10}H_{21}NO$	1-Ethylconhydrine		0.9345^{20}_{4}		−45.2	(1893)
$C_{11}H_{23}N$	*l*-*N*-Isoamyl-2-pipecoline		0.8310^{19}		−88.86	(914.8)
$C_{11}H_{23}N$	*N*-Propylconiine		0.8423^{18}		76.21	(915)
$C_{11}H_{23}NO$	1-Propylconhydrine		0.9172^{20}_{4}		−50.1	(1893)
$C_{12}H_{17}N$	*d*-2-Phenyl-6-methylpiperidine		0.9497^{20}_{20}		44.81	(1892)
	d-2-Isophenyl-6-methylpiperidine				0.92	
$C_{12}H_{25}N$	*N*-Butylconiine		0.8393^{20}_{4}		72.6	(1885)
$C_{13}H_{27}N$	*N*-Isoamylconiine		$0.8352^{23.5}$		75.14	(915)
$C_{13}H_{27}NO$	1-Isoamylconhydrine		0.9087		−45.1	(1893)
$C_{15}H_{21}NO$	Benzoylconiine		1.0623^{16}	16	29.1	(1149)
$C_{15}H_{23}N$	*N*-Benzylconiine ($C_8H_{16}N.CH_2.C_6H_5$)		0.9461^{20}_{4}	20	72.9	(1884)
$C_{17}H_{23}NO_2$	Coniine phenylpropiolate	$CHCl_3$	4	21	−7.12	(901)
		H_2O	4	24	1.00	
$C_{17}H_{25}NO_2$	Coniine cinnamate	$CHCl_3$	4	22	−7.50	(901)
		$CHCl_3$	1	22	8.50	
		H_2O	4	24	1.75	
$C_{17}H_{27}NO_2$	Coniine β-phenylpropionate	$CHCl_3$	4	27	−1.87	(901)
		$CHCl_3$	1	27	2.00	
		H_2O	4	24	2.50	
$C_{20}H_{34}INO$	α-Benzylisoamylconhydrinium iodide	EtOH	*5*	20	−40	(1893)
	β-Benzylisoamylconhydrinium iodide	EtOH	*5*	20	−50	(1893)
$C_{20}H_{36}N_2O_4$	Diconiine acetylenedicarboxylate	$CHCl_3$	4	22	3.37	(901)
		H_2O	4	24	1.00	
$C_{20}H_{38}N_2O_4$	Diconiine maleate	$CHCl_3$	4	18	4.38	(901)
		H_2O	4	24	2.00	
$C_{20}H_{38}N_2O_4$	Diconiine fumarate	$CHCl_3$	4	22	4.00	(901)
		H_2O	4	24	1.75	
$C_{20}H_{40}N_2O_4$	Diconiine succinate	$CHCl_3$	4	22	5.12	(901)
		H_2O	4	24	1.50	

Tetrahydroquinaldine and derivatives

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_9H_{11}N$	*l*-Dihydro-α-methylindole  $\left(C_6H_4\begin{matrix}CH_2\\NH\end{matrix}CH.CH_3\right)$	EtOH	3.80		7.22	(1661)
		Et_2O	5.24		−13.53	
		C_6H_6	3.47		8.25	
$C_9H_{12}ClN$	*l*-Dihydro-α-methylindole hydrochloride	H_2O	4.15		1.68	(1661)
$C_{10}H_{13}N$	*l*-Tetrahydroquinaldine, tetrahydro-α-methylquinoline,  $\left(C_6H_4\begin{matrix}CH_2.CH_2\\ \vert\\NH.CH.CH_3\end{matrix}\right)$		1.0236	20	−58.12	(1671, 1672)
		Et_2O	2.51	21.0	−50.8	
		Me_2CO	2.54	19.5	−63.3	
	In methyltetrahydroquinoline		18.77	19.0	−63.6	

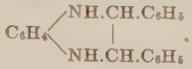
Tetrahydroquinaldine and derivatives.—(Continued)

Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{13}N$	*l*-Tetrahydroquinaldine.—(*Cont'd*)...........		6.70	24.2	−58.9	
	In tetrahydroquinoline....................	EtOH	2.56	21.5	−64.0	
		MeOH	2.53	19.5	−75.1	
		$CHCl_3$	2.59	21.5	−85.3	
		C_6H_6	2.56	21.0	−88.6	
		CCl_4	2.53	21.5	−97.6	
		AcOH	2.61	21.0	−117.9	
		$C_5H_{11}N$	8.25	23.8	−45.9	
$C_{11}H_{13}NO$	*l*-Acetyldihydro-*α*-methylindole............	EtOH	1.36		−61.9	(1661)
$C_{11}H_{15}N$	*l*-Tetrahydro-*p*-toluquinaldine..............	C_6H_6	1.98	21	−80.9	(1688)
		Me_2CO	2.14	18	−59.1	
		EtOH	2.12	18	−67.6	
		$CHCl_3$	1.99	18	−78.8	
	d-Tetrahydro-*p*-toluquinaldine.............	H_2O	2.03	18	70.3	
		C_6H_6	1.94	19	80.7	
$C_{12}H_{17}N$	1-Ethyl-2-methyltetrahydroquinoline.......		0.9942^{20}	20	12.1	(1893)
$C_{14}H_{15}N$	*d*-Tetrahydro-*β*-naphthoquinaldine..........	EtOH (abs.)	0.670	29.5	109.0	(719)
		C_6H_6	0.499	29.5	157.0	
	l-Tetrahydro-*β*-naphthoquinaldine..........	EtOH (abs.)	0.647	29.5	−108.5	
$C_{16}H_{15}NO$	*l*-Benzoyldihydro-*α*-methylindole...........	EtOH	1.64		−37.1	(1661)
$C_{18}H_{19}NO$	Benzoyl-*l*-tetrahydro-*p*-toluquinaldine.......	C_6H_6	2.05	18	229	(1688)
$C_{21}H_{19}NO$	Benzoyl derivative of *l*-tetrahydro-*β*-naphthoquinaldine (dextro base)........	EtOH (abs.)	0.362	29.5	−587.0	(719)
	(levo base)............................	EtOH (abs.)	0.351	29.5	587.6	
	POLYBASIC AMINES					
	Nicotine and derivatives					
$C_{10}H_{14}N_2$	Nicotine  $\left(\begin{array}{l}CH_2.CH_2\\ \mid\\ CH_2.N.CH_3\end{array}\!>CH.C\begin{array}{l}\nearrow CH.CH\searrow\\ \searrow CH{:}N\nearrow\end{array}CH\right)$	H_2O	4.795		−77.9	(268)
		50% EtOH	4.368		−104.2	
		EtOH	21	20	−30	(385); *cf.* (2200)
	($[\alpha]_D$ calculated on *C* at 20° C)..........	EtOH	21	−50	−28.7	
	($[\alpha]_D$ calculated on *C* at 20° C)..........	EtOH	21	−70	−27.3	
	($[\alpha]_D$ calculated on *C* at 20° C)..........	EtOH	21	−90	−25.3	
	($[\alpha]_D$ calculated on *C* at 20° C)..........	EtOH	21	−120	−22	
$C_{14}H_{20}N_2O_6$	*d*-Nicotine *l*-tartrate....................	H_2O	7.96	15	−25.58	(1645); *cf.* (1639)
	l-Nicotine *d*-tartrate....................	H_2O	8.57	15	27.16	
	Other polybasic amines					
$C_{13}H_{16}N_2O_6$	Tetrahydroxybutyl-*N*-phenylhydantoin*....	H_2O	1.95		93.2	(1498)
$C_{18}H_{36}N_2$	Ethylene-*bis*-*d*-coniine†....................	MeOH	1.825		81.09	(2152)
$C_{20}H_{18}N_2$	*l*-2, 3-Diphenyl-1, 2, 3, 4-tetrahydro-quinoxaline‡..........................	EtOH	0.799	20	−40.8	(109)
$C_{33}H_{32}BrN_3O_4S$	*l*-2, 3-Diphenyl-2, 3-dihydro-1, 3, 4-naphthaisotriazine *d*-*α*-bromocamphor-*π*-sulfonate§	Me_2CO	2.8	20	23.8	(1689)
		EtOH	2.8	20	25.7	
		$CHCl_3$	2.8	20	−1.3	
	AMINO ACIDS					
	Proline and derivatives‖					
$C_5H_9NO_2$	*l*-Proline *l*-pyrrolidine-2-carboxylic acid,  $\begin{array}{l}CH_2.NH\\ \mid\\ CH_2.CH_2\end{array}\!>CH.COOH$..................	H_2O	*7.93*	20	−77.40	(469)
		20% HCl	*7.68*	20	−46.53	
		0.5*N* NaOH	*5.73*	20	−83.48	
	l-Proline (synthetic)......................	H_2O	*6.46*	20	−80.9	(561.2)
		0.6*N* KOH	*2.35*	20	−93.0	
	d-Proline (synthetic)......................	H_2O	*3.865*	20	+81.5	(561.2)
$C_7H_{13}NO_3$	Betonicine¶............................	H_2O	4.88	15	−36.60	



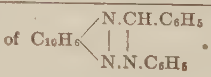
$$^{*}\ H(CHOH)_4.CH\left\langle\begin{array}{l}NH.CO\\ \qquad\mid\\ CO.N.C_6H_5\end{array}\right.$$

, from glucosamine. † $C_8H_{16}N.CH_2.CH_2.N.C_8H_{16}$.



$$‡\ C_6H_4\left\langle\begin{array}{l}NH.CH.C_6H_5\\ \qquad\mid\\ NH.CH.C_6H_5\end{array}\right.$$

. § Salt of



$$C_{10}H_6\left\langle\begin{array}{l}N.CH.C_6H_5\\ \ \mid\quad\mid\\ N.N.C_6H_5\end{array}\right.$$

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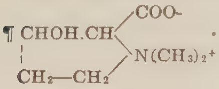
‖ For polypeptides containing proline, *see* p. 377, 378.



$$¶\ \begin{array}{l}CHOH.CH\left\langle\begin{array}{l}COO^-\\ \\ N(CH_3)_2{}^+\end{array}\right.\\ \mid\\ CH_2{-}CH_2\nearrow\end{array}$$

.

Proline and derivatives.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_7H_{14}ClNO_3$	Betonicine hydrochloride	H_2O	8.58	15	−24.79	
$C_7H_{13}NO_3$	Turicine (stereoisomer of betonicine)	H_2O	12.05		36.26	(1139)
$C_7H_{14}ClNO_3$	Turicine hydrochloride	H_2O	7.18		24.65	(1139)
$C_{11}H_{17}NO_3$	α-Hydroxyisohexoyl-*l*-prolinolactone	AcOH	*2.92*	20	−166.8	(540)
$C_{11}H_{20}N_2O_3$	α-Hydroxyisohexoyl-*l*-prolinamide*	H_2O	*2.69*	20	−78.6	(540)
$C_{12}H_{12}N_2O_5$	*d*-*m*-Nitrobenzoylproline	*N* NaOH	*3.95*	20	+120.0	(561.2)
	Other cyclic amino acids					
$C_4H_6N_2O_3$	Glyoxalid-2-on-5-carboxylic acid†	H_2O	*2.1*	18	−16.5	(1040)
$C_8H_{13}NO_4$	*l*-Tropinic acid‡	H_2O	*6.5*	20	−15.2	(699)
$C_9H_{14}O$	*d*-3-Acetyl-1-methyl-Δ^2-cyclohexene		0.9413^{22}_{22}		100.4	(841)
$C_{11}H_{21}NO_2$	Methylconiinyl *N*-acetate§		0.9726	20	62.1	(1884)
$C_{22}H_{23}NO_7$	*d*-Narcotine	$CHCl_3$	2.606		199.9	(1602); *cf.* (725, 1601.8)
	l-Narcotine	$CHCl_3$	3.356		−199.3	
$C_{32}H_{38}BrNO_{11}S$	*dl*-Narcotine *d*-bromocamphorsulfonate	$CHCl_3$	2.155		20.2	(1602)
	l-Narcotine *d*-bromocamphorsulfonate	$CHCl_3$	2.248		100.7	
	d-Narcotine *l*-bromocamphorsulfonate	$CHCl_3$	3.319		−97.2	
	l-Narcotine *l*-bromocamphorsulfonate	$CHCl_3$	2.662		29.01	

IIC. The Molecule Contains Asymmetric Atoms Attached Each to Three Other Carbon Atoms

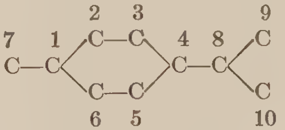
HYDROCARBONS

Monocyclic Hydrocarbons

Cyclic hydrocarbons not related directly to menthane

C_6H_{10}	Methyl-Δ^2-cyclopentene		0.7663	18	27.22	(2232)
C_7H_{12}	1-Methyl-$\Delta^{2(3)}$-cyclohexene		0.7937^{27}_4		81.47	(2232)
$C_7H_{10}Br_2$	1-Methyl-$\Delta^{2,4}$-cyclohexadiene dibromide		0.8274^{20}_4		36.42	(2234)
C_8H_{12}	1, 3-Dimethyl-$\Delta^{2,4}$-cyclohexadiene		0.8225^{20}_4		27.38	(2235)
C_8H_{14}	Laurolene (Δ^1-1, 2, 3-trimethylcyclopentene)		$0.8008^{17.5}$		23.8	(2026)
			0.8030^{15}_4	23	22.8	(1517)
			0.7991^{20}_{20}	26.2	28.15	(1518)
C_8H_{14}	1, 3-Dimethyl-$\Delta^{2(3)}$-cyclohexene		0.8015^{22}_4		95	(2237.5); *cf.* (2232)
C_8H_{14}	*l*-1-Methyl-3-methylenecyclohexane	EtOH	*14.4*	15	−30.22	(2117)
C_9H_{16}	1-Methyl-3-ethyl-$\Delta^{2(3)}$-cyclohexene		0.8087^{25}_4		56.8	(2237.5); *cf.* (2232)
C_9H_{16}	*l*-1-Methyl-3-ethylidenecyclohexane		0.8135^{19}_{19}		−50	(841)
C_9H_{16}	1-Methylcyclohexylidene-3-ethane		0.8154^{19}_4		56.63	(2236)
$C_{10}H_{18}$	1-Methyl-3-propylidenecyclohexane		0.814	19	−42.3	(2120)
$C_{11}H_{18}$	*d*-1-Methyl-3-dimethylvinyl-Δ^3-cyclohexene		0.846^{15}_4		68.8	(837.5)
			0.8445^{15}_4		63.9	
	d-1-Methyl-3-dimethylvinyl-Δ^2-cyclohexene		0.8531^{15}_4		54.8	
$C_{11}H_{20}$	1, 3-Dimethyl-4-isopropyl-$\Delta^{2(3)}$-cyclohexene		0.8192^{26}_4		88.53	(2237.5); *cf.* (2232)
$C_{16}H_{22}$	1-Phenyl-5-methyl-2-isopropenylcyclohexane		$0.9462^{15.7}_4$		17	(1093)
$C_{16}H_{22}$	1-Methyl-3-phenyl-4-isopropylcyclohexene		0.9621^{20}		13.9	(1481)
$C_{16}H_{28}$	1-Methyl-3-cyclohexyl-4-isopropylcyclohexene		0.9198^{14}		6.2	(1481)
$C_{18}H_{24}$	Phenylbutadienyltrimethylcyclopentane	C_6H_6	*9.91*	20	3.86	(1827)

Menthane and hydrocarbon derivatives, excluding natural terpenes



$C_{10}H_{16}$	*d*-$\Delta^{5,8,(9)}$-Menthadiene	AcOEt	4.562	17	29.6	(1600)
$C_{10}H_{16}$	*d*-$\Delta^{2,8(9)}$-*m*-Menthadiene		0.864^{17}_{17}	17	64.0	(841)
	$\Delta^{3,8(9)}$-Menthadiene		0.8420^{20}		17.6	(1931)
	d-$\Delta^{3,8(9)}$*m*-Menthadiene	AcOEt	3.558		17.5	(1312)
	l-$\Delta^{3,8,(9)}$*m*-Menthadiene	AcOEt	4.059		−12.9	(1312)
	d-$\Delta^{3,8(9)}$*p*-Menthadiene	AcOEt	4.272		>100.0	(288)
		C_6H_6		18	98.2	(1048)

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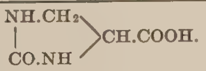
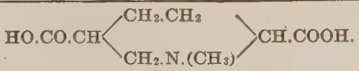
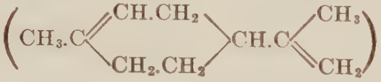
* $C_4H_9.CHOH.CO.NC_4H_7.CO.NH_2$.

† 
$\begin{matrix} NH.CH_2 \\ | \\ CO.NH \end{matrix}\Big>CH.COOH.$

‡ 
$HO.CO.CH\Big<\begin{matrix} CH_2.CH_2 \\ CH_2.N.(CH_3) \end{matrix}\Big>CH.COOH.$

§ $C_8H_{16}N.CH_3.HO.OCCH_3$.

Menthane and hydrocarbon derivatives, excluding natural terpenes.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{18}$	*d*-Menthene; *cf.* (296, 1947, 1966)			20	115.64	(306); *cf.* (114)
	l-Menthene		0.816^{20}_{20}	20	−38	
$C_{10}H_{18}ClNO$	Carvomenthene nitrosochloride	Et_2O	5.59		724*	(2063.5)
	(λ = 5780)	Et_2O	5.59		344	
$C_{10}H_{20}$	*m*-Menthane†		0.8116	23	1.6	(1852)
$C_{11}H_{16}$	2-Methyl-$\Delta^{2,6,8,(9)}$-menthatriene		0.8724	21.1	69.12	(1089)
$C_{11}H_{16}$	2-Methylmenthatriene		0.8776^{15}_{4}	21	69.12	(1090)
$C_{11}H_{16}$	Methylmenthatriene		0.8747^{20}	20	103.49	(1825)
$C_{11}H_{18}$	3-Methyl-$\Delta^{2,8(9)}$-menthadiene		0.8400	20	46.27	(1824)
$C_{11}H_{18}$	3-Methyl-$\Delta^{1,4(8)}$-menthadiene		0.840^{20}	20	−96.89	(1826)
$C_{11}H_{18}$	Methylmenthadiene		0.8576^{20}	20	−55.44	(1825)
$C_{12}H_{18}$	2-Ethylmenthatriene		0.8880^{15}_{4}	18	86.19	(1090)
$C_{13}H_{20}$	2-Propyl-$\Delta^{2,5,8(9)}$-menthatriene		0.8804^{15}_{4}	22	86.20	(1090)
$C_{16}H_{18}$	2-Phenyl-$\Delta^{2,6,8(9)}$-menthatriene		$0.9882^{13.8}_{4}$	13.8	110.2	(1089)
	Limonene and derivatives					
$C_{10}H_{16}$	*d*-Limonene ($\Delta^{1,8,9}$-*p*-menthadiene,			20	124.77	(306)
	 $\left(CH_3.C\begin{smallmatrix}CH.CH_2\\CH_2.CH_2\end{smallmatrix}CH.C\begin{smallmatrix}CH_3\\CH_2\end{smallmatrix}\right)$	MeOH	9.27	20	109.3	(2100)
		MeOH	0.36	20	107.1	
		EtOH	10.59	20	112.00	
		EtOH	0.449	20	111.4	
		Me_2CO	10.36	20	112.5	
		Me_2CO	0.523	20	115.0	
		AcOEt	9.21	20	112.9	
		AcOEt	0.47	20	114.8	
		CCl_4	10.10	20	112.6	
		CCl_4	0.427	20	113.0	
		C_6H_6	11.14	20	122.1	
		C_6H_6	0.523	20	117.6	
	l-Limonene				−113.8	(596); *cf.* (2109, 2128)
	d-Limonene				120.6	
$C_{10}H_{16}Br_4$	*l*-Limonene tetrabromide	$CHCl_3$	22.24		−74.6	(229)
$C_{10}H_{16}ClNO$	*d*-Limonene-α-nitrosochloride	$CHCl_3$	*21.13*	17	304.0	(2107, 2128); *cf.* (1324.2, 2109)
$C_{10}H_{16}ClNO$	*d*-Limonene-β-nitrosochloride	$CHCl_3$	*5.34*	10.5	240.3	
$C_{10}H_{16}N_4O$	*d*-Limonene nitrosoazide	$CHCl_3$	1.188		6.5	(596); *cf.* (596.5)
$C_{10}H_{18}$	Dihydrolimonene		(λ = 5780)		118	(2062)
			(λ = 4360)		234	
$C_{10}H_{18}Br_2$	Dihydrolimonene dibromide		(λ = 5780)		49	(2062)
			(λ = 4360)		100	
$C_{10}H_{18}ClNO$	Dihydrolimonene nitrosochloride		(λ = 5780)		344	(2062)
			(λ = 4360)		724	
$C_{11}H_{18}$	2-Methyllimonene				−7.99	(1825)
			0.8598^{20}		−25.33	
$C_{11}H_{18}N_2O_2$	*d*-Limonene α-nitrosocarboxamide	$CHCl_3$	2.02	17	174.9	(1179)
$C_{17}H_{21}N_5O_2$	*l*-Limonene nitrosoazidephenylcarbamyloxime	$CHCl_3$	1.187		−120.8	(596)
	d-Limonene nitroazidephenylcarbamyloxime	$CHCl_3$	1.108		118.8	
$C_{18}H_{20}N_2O_2$	Benzoyl-*d*-limonene α-nitrosocyanide	$CHCl_3$	2.04	15	127.2	(1179)
	Benzoyl-*d*-limonene β-nitrosocyanide	$CHCl_3$	2.02	18	−108.2	
$C_{18}H_{22}N_2O_3$	Benzoyl-*d*-limonene α-nitrosocarboxamide	$CHCl_3$	1.67	19	241.7	(1179)
	Sylvestrene, phellandrene and other monocyclic terpenes					
$C_{10}H_{14}$	*l*-Verbenene		0.8822^{20}	19	−84.9	(154)
$C_{10}H_{16}$	Sylvestrene; *cf.* (65, 1143, 2031, 2128)		0.8625^{21}_{0}	21	15.6	(1852)
	d-Sylvestrene	AcOEt	5		67.5	(840)
	l-Sylvestrene	AcOEt	5		−68.2	
$C_{10}H_{16}$	*d*-Phellandrene		0.8558	10	17.64	(1607.5)

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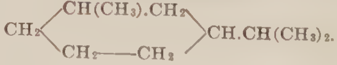
* $[\alpha]_{4359}$.

†  $CH_2\begin{smallmatrix}CH(CH_3).CH_2\\CH_2—CH_2\end{smallmatrix}CH.CH(CH_3)_2$.

Sylvestrene, phellandrene and other monocyclic terpenes.—(*Continued*)

Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{18}Cl_2$	*d*-Sylvestrene dihydrochloride	AcOEt	5		22.5	(840)
	l-Sylvestrene dihydrochloride	AcOEt	5		−21.8	
	DICYCLIC HYDROCARBONS					
	Pinene and pinolene					
$C_{10}H_{16}$	β-Pinene		0.8630^{21}	20	15.93	(2118)
		Et_2O	13.64	20	12.76	
	l-Pinene* } *cf.* (65, 83, 117, 364, 566, 567,			20	−40.0	(306); *cf.*
	d-Pinene* } 1776, 1783, 2128, 2209)		0.8635_4^{14}	14	39.4	(83)
$C_{10}H_{16}$	Pinolene		0.8599_4^{20}	20	1.63	(59)
$C_{10}H_{16}O_3$	Pinene ozonide	$CHCl_3$	*52.5*	20	11.67	(832)
$C_{10}H_{17}Br$	*d*-Pinene hydrobromide	EtOH	8	21	31.31	(2042)
$C_{10}H_{17}Cl$	*d*-Pinene hydrochloride	EtOH	8	17	33.19	(2042)
$C_{10}H_{17}Cl$	Pinolene hydrochloride	C_6H_6	*18.9*	20	9.78	(59)
	Isopinolene hydrochloride	C_6H_6	*18.9*	20	9.18	
$C_{10}H_{18}$	Pinane (from pinenes by various methods)		0.8519	17.5	−16.1	(1256.5)
			0.8566	20	23.08	
			0.8562	20	−18.9	
	Camphene and bornylene					
$C_{10}H_{15}NO_2$	*l*-Nitrocamphene	C_6H_6	*20*	20	−146.4	(1256)
$C_{10}H_{16}$	*d*-Camphene;† *cf.* (120, 125.5, 171, 735, 1034, 1158, 1391, 1447, 1779, 1980)	EtOH	10	25	83.5	(2042)
		C_6H_6	20	28	84.05	
		Me_2CO	20	27	83.8	
	l-Camphene	PhMe	17.87	20	−95.56	(306)
$C_{10}H_{16}$	Camphene (American)	C_6H_6	*20.2*	20	17.95	(60)
		C_6H_6	*50*	20	74.55	
	From bornyl toluene-*p*-sulfonate	EtOH	2.064	20	38.8	(451)
		EtOH	2.064	20	38.9	
	From Siberian pinewood oil	Et_2O	*11.36*	18	−84.9	(2118)
	From bornylamine	Et_2O	*9.67*	17	103.89	
$C_{10}H_{18}$	Isocamphane (liquid); *cf.* (84, 565, 1143, 1161, 1608, 1778)	MeOH	10	19	1.15	(1255)
$C_{16}H_{20}$	β-Phenylcamphene		0.9736_{11}^{18}		7.25	(802)
$C_{20}H_{34}$	*d*-Hydrodicamphene	C_6H_6	20		28.70	(896)
	Fenchene and other dicyclic terpenes					
$C_{10}H_{16}$	Fenchene (from fenchyl chloride)		0.8631_4^{21}	20	−9.65	(1130); *cf.* (1124)
$C_{10}H_{16}$	*D*-*l*-Fenchene		0.869^{19}	18	−37.1	(2130)
$C_{10}H_{16}Br_2$	*D*-*l*-Fenchene dibromide	AcOEt	*3.56*	11	42.83	(2130)
$C_{11}H_{18}$	Methylfenchene		0.8638_4^{27}		19.68	(2237.5)
	SESQUITERPENES					
$C_{15}H_{24}$	Isozingiberene (bicyclic)		0.9118	20	−51.60	(1926)
$C_{15}H_{24}$	Metazingiberene		0.8927^{20}	20	6.5	(1926)
$C_{15}H_{24}$	Selinene (from dihydrochloride)		0.9190_0^{20}		61.36	(1932)
$C_{15}H_{24}N_2O_3$	β-Caryophyllene nitrosite	C_6H_6	*0.4729*		1625.0	(381)
		ligroin	*0.01713*		1661.0	
$C_{15}H_{25}ClN_2O_4$	β-Hydrochlorocaryophyllene nitrosite	C_6H_6	*0.5266*	21	930.4	(381)
$C_{15}H_{26}$	Dihydrozingiberene		0.8557^{20}	20	−37	(1926)
$C_{15}H_{28}$	Tetrahydroisozingiberene (bicyclic)		0.8822	20	4.60	(1926)
$C_{15}H_{28}$	Tetrahydroselinene		0.8889_{20}^{20}		1.12	(1932)
			0.8881^{20}		7	
$C_{15}H_{30}$	Hexahydrozingiberene		0.8264	20	−10.20	(1926)
$C_{30}H_{48}$	Dizingiberene		0.9287	20	−5	(1926)

ALCOHOLS

Monohydric Alcohols

Alcohols not derived directly from terpenes

Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_9H_{18}O$	1-Methyl-3-ethylcyclohexan-3-ol		0.8995_4^{21}		1.48	(2231)
$C_{11}H_{20}O$	*d*-1-Methyl-3-isobutanol-Δ^3-cyclohexene‡	Me_2CO			49.5	(837.5)
	d-1-Methyl-3-isobutanol-Δ^2-cyclohexene§	Me_2CO	0.8		68.2	
$C_{16}H_{24}O$	1-Methyl-3-phenyl-4-isopropyl-3-cyclohexanol		0.9843	20	−16.32	(1481)

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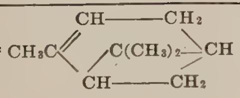

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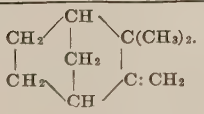

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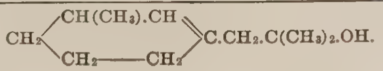

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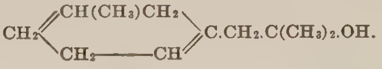

Alcohols derived from menthol (for menthol itself (IIC_2B), see p. 420)

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_{10}H_{18}O$	*d*-Δ^5-*m*-Menthenol (8)	EtOH	4.405	16	36.7	(1600)
	d-Δ^6-*m*-Menthenol (8)	AcOEt	5		−2.7	(840)
	d-Δ^3-*m*-Menthenol (8)	AcOEt	3.62		20.9	(1312)
	d-Δ^3-*p*-Menthenol (8) *cf.* (173.5, 434.5, 565, 566, 1158, 1158.5, 1491, 2029)	AcOEt	4.55		83.2	
		C_6H_6		18	67.0	(1048)
	d-Δ^2-*m*-Menthenol (8)		0.923_{22}^{22}		55.56	(841)
	l-Δ^1-*m*-Menthenol (8)	AcOEt	5		−45.9	(840)
$C_{11}H_{18}O$	2-Methyl-$\Delta^{6,8(9)}$-menthadiene-2-ol		$0.9471_4^{20.4}$	20.4	36.08	(1089)
$C_{13}H_{22}O$	2-Propyl-$\Delta^{6,8(9)}$-menthadiene-2-ol		0.9178_4^{21}	21	49.16	(1090)
$C_{16}H_{20}O$	2-Phenyl-$\Delta^{6,8(9)}$-menthadiene-2-ol		$1.0156_4^{15.1}$	15.1	81.42	(1089)
	Terpene alcohols					
$C_{10}H_{13}N$	Myrtenyl nitrile		0.967^{20}	20	46	(1924)
$C_{10}H_{15}Cl$	Myrtenyl chloride		1.015^{20}	20	23.6	(1924)
$C_{10}H_{16}O$	Myrtenol		0.9763^{20}	20	46.8	(1924)
$C_{10}H_{18}O$	Isopulegol		0.9154	17.5	−2.66	(1491)
$C_{10}H_{18}O$	Methylcamphenilol	EtOH	*41.42*	18.5	16.6	(61)
$C_{10}H_{18}O$	Homonopinol (pinene hydrate)	Et_2O	*17.85*	18	−4.99	(2127)
$C_{10}H_{20}O$	Dihydrofencholenyl alcohol		0.8869^{22}		11.3	(1919)
$C_{10}H_{20}O$	*d*-(1)-Dihydrosylveterpineol	MeOH			1.96	(842)
$C_{10}H_{20}O$	Tetrahydroumbellulol		0.9071_{16}^{15}	15	−6.6	(1183)
$C_{11}H_{20}O$	3-Methylisopulegol		0.9108^{20}	20	19.54	(1824)
$C_{12}H_{20}O_2$	Methylcamphenilyl acetate*		1.003	18	18.9	(61)
$C_{18}H_{22}O_4$	Myrtenyl hydrogen phthalate	EtOH	*50*		21.6	(1924)
	DIHYDRIC ALCOHOLS					
$C_{10}H_{20}O_2$	Sylveterpine	MeOH	*8.12*	15	27.43	(2118)
$C_{10}H_{20}O_2$	α-Sylveterpine	$CHCl_3$			−27.74	(842)
	β-Sylveterpine	$CHCl_3$			20.93	
		MeOH			18.48	
	POLYHYDRIC ALCOHOLS					
$C_{22}H_{24}O_7$	Acetyltetramethylhematoxylin	AcOH	1.01	20	159.19	(863)
	KETONES					
	KETONES NOT DERIVED DIRECTLY FROM TERPENES					
	Cyclopentanones					
$C_6H_{10}O$	3-Methylcyclopentan-1-one		0.9140_4^{19}		156.3	(2232)
$C_6H_{11}NO$	3-Methylcyclopentanoneoxime	H_2O	*2.41*	20	75.15	(2112)
	3-Methylcyclopentanone-α-isooxime	H_2O	*25.59*	20	−36.12	
	3-Methylcyclopentanone-β-isooxime	H_2O	*5.28*	20	−22.20	
$C_7H_{12}O$	2, 3-Dimethylcyclopentanone		0.8914_4^{19}	19	126.7	(808); *cf.* (2232)
$C_8H_{14}O$	2, 2, 3-Trimethylcyclopentanone		0.8778_4^{19}	19	103.7	(808)
$C_9H_{16}O$	2, 3, 6, 6-Tetramethylcyclopentanone		0.8668_4^{19}	19	70.1	(808)
$C_{10}H_{16}O$	3, 6-Dimethyl-2-allylcyclopentanone		0.8968_4^{20}	20	71.7	(808)
$C_{10}H_{18}O$	2, 2, 3, 6, 6-Pentamethylcyclopentanone			20	32.9	(808)
$C_{10}H_{18}O$	4-Methyl-2-isobutylcyclopentanone	Et_2O	*1.72*		62	(386)
$C_{13}H_{20}O$	3, 6-Dimethyl-2, 6-diallylcyclopentanone		0.8994_4^{20}	20	74.7	(808)
$C_{16}H_{24}O$	3, 6-Dimethyl-2, 2, 6-triallylcyclopentanone		0.9179_4^{20}	20	73.2	(808)
	Cyclohexanones					
$C_7H_{12}O$	3-Methylcyclohexan-1-one				12.7	(306)
		C_6H_6	11.37		11.96	
		MeOH	11.47		8.15	
		EtOH	10.97		10.58	
			0.9173	15.3	13.33	(2113)
		EtOH	*9.29*	14	10.45	
		$CHCl_3$	*14.77*	12	14.77	
		CCl_4	*37.22*	12.5	11.86	
		Et_2O	*24.8*	15	17.44	
$C_7H_{13}NO$	3-Methylcyclohexanoneoxime	Et_2O	*11.70*	21	−42.05	(2113)
		MeOH	*9.98*	22	−42.07	
$C_8H_{14}O$	3, 6-Dimethylcyclohexanone		0.9083^{13}		11.6	(1200)
$C_9H_{16}O$	3-Methyl-6-ethylcyclohexanone		0.9016	15	8.53	(795)
$C_{10}H_{16}O$	3-Methyl-6-allylcyclohexanone		0.9233	15	18.03	(795)
$C_{10}H_{18}O$	3-Methyl-6-propylcyclohexanone		0.8994	15	3.35	(795)

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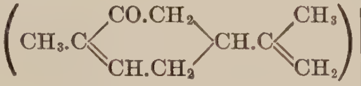
* $CH_3.C_9H_{14}.O.CO.CH_3$.

Cyclohexanones.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{11}H_{20}O$	3-Methyl-6-isobutylcyclohexanone		0.9950	15	0.40	(795)
$C_{11}H_{20}O$	2, 2, 3, 6, 6-Pentamethylcyclohexanone		0.8979^{20}		24	(800)
$C_{13}H_{20}O$	3-Methyldi-6, (?)-allylcyclohexanone		0.9365	15	62.03	(795)
$C_{14}H_{17}NO_2$	Benzoyl-3-methylcyclohexanoneoxime, *α*-	Et_2O	*7.49*	22	19.97	(2113)
	β-	Et_2O	*7.23*		−86.08	
$C_{14}H_{18}$	6-Benzylidene-3-methylcyclohexanone	EtOH	1.35		−152	(794)
$C_{15}H_{18}O_2$	6-Anisylidene-3-methylcyclohexanone	EtOH	0.525		−225	(794)
$C_{16}H_{26}O$	3-Methyl-2, 2-diallyl-6-isopropylcyclohexanone				25.50	(800)
$C_{17}H_{22}O$	6-Cuminylidene-3-methylcyclohexanone	EtOH	1.51		−165	(794)
$C_{19}H_{28}O$	3-Methyl-2, 2, 6, 6-tetraallylcyclohexanone		0.954	15	36.17	(800)
	Other ketones not derived directly from terpenes					
$C_{10}H_{16}O$	*d*-1-Methyl-3-acetonyl-Δ^3-cyclohexene*	Me_2CO	1.0		82.8	(837.5)
	d-1-Methylacetonyl-Δ^2-cyclohexene†	Me_2CO			60.7	
$C_{11}H_{19}N_3O$	*d*-1-Methyl-3-acetonyl-Δ^3-cyclohexene semicarbazone	Me_2CO	*0.75*		70.4	(837.5)
	d-1-Methyl-3-acetonyl-Δ^2-cyclohexene semicarbazone	Me_2CO			57.8	
	KETONES DERIVED FROM TERPENES					
	Carvone and derivatives					
$C_{10}H_{14}O$	*d*-Carvone 		0.9567		173.8	(71)
			0.959	20	62.2	(143); *cf.* (570, 2055)
	l-Carvone	$CHCl_3$	10	20	−62.46	
$C_{10}H_{14}OS$	*d*-Carvone thiolsulfide	$CHCl_3$	10	20	5.5	(143); *cf.* (306)
	l-Carvone thiolsulfide	$CHCl_3$	10	20	−5.5	
$C_{10}H_{15}N_3O$	*d*-Triazodihydrocarvone				88.49	(596)
		$CHCl_3$	4.117		94.4	
	l-Triazodihydrocarvone				−92.47	
		$CHCl_3$	4.139		−94.22	
$C_{10}H_{16}O$	Dihydrocarvone			20	18.28	(306)
$C_{10}H_{16}O_2$	8-Hydroxy-8, 9-dihydrocarvone	EtOH	*9.96*	20	43.06	(1841)
$C_{10}H_{18}O$	Tetrahydrocarvone (λ = 5780)		0.904	20	−40.5	(2063)
$C_{11}H_{15}Br_2NO$	*α*-Cyanodihydrocarvone dibromide	EtOH	1.59	18	29.0	(1169)
$C_{11}H_{15}NO$	*β*-Cyanodihydrocarvone	EtOH	1.447		−42.1	(1174)
	Neocyanodihydrocarvone	EtOH	1.340	12	62.7	
$C_{11}H_{15}NO$	Cyanodihydrocarvone	EtOH	1.68	12	13.5	(1169)
$C_{11}H_{16}N_2O$	*α*-Cyanodihydrocarvoxime	EtOH	1.59	17	14.2	(1169)
	β-Cyanodihydrocarvoxime	EtOH	1.59	17	6.0	
$C_{11}H_{16}O_3$	*α*-Dihydrocarvonecarboxylic acid	AcOEt	1.63	16.5	49.9	(1169)
	β-Dihydrocarvonecarboxylic acid	AcOEt	1.62	35	28.8	
$C_{11}H_{17}N_3O$	Carvone semicarbazone (M. P. 162)	Py	*5.12*	20	115.1	(1823)
	(M. P. 141–142)	Py	*5.00*	20	113.3	
$C_{17}H_{20}O_2$	*β*-Benzoyldihydrocarvone	EtOH	0.995	18	−50.7	(327)
	On adding *M* NaOEt	EtOH	0.995	18	−40.2	
$C_{23}H_{25}NO$	*β*-Phenyliminobenzoyldihydrocarvone	EtOH	1.00	17	−369	(327)
	Carvoxime and derivatives					
$C_{10}H_{15}NO$	*β*-Carvoxime	C_6H_6			68.3	(380); *cf.* (2107)
$C_{10}H_{15}NO$	*d*-Carvoxime	EtOH	*9.84*	20	39.6	(728); *cf.* (382, 727.5)
$C_{12}H_{17}NO_2$	Acetyl-*d*-carvoxime	C_6H_6	*10.03*		43.0	(728)
$C_{14}H_{19}NO_2$	Crotonyl-*d*-carvoxime	C_6H_6	*10.00*	20	33.5	(1812)
$C_{17}H_{18}BrNO_2$	*o*-Bromobenzoyl-*d*-carvoxime	$CHCl_3$	*5.469*	22.0	26.0	(728)
	m-Bromobenzoyl-*d*-carvoxime	$CHCl_3$	*5.513*	23.5	18.2	
	p-Bromobenzoyl-*d*-carvoxime	$CHCl_3$	*5.496*	23	14.9	

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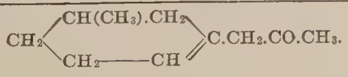
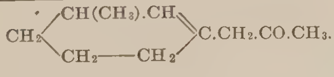
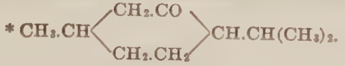
* 

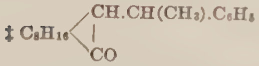
† 

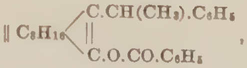
Carvoxime and derivatives.—(Continued)

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_{17}H_{18}N_2O_4$	*o*-Nitrobenzoyl-*d*-carvoxime	$CHCl_3$	*4.704*	20	±0.00	(728)
	m-Nitrobenzoyl-*d*-carvoxime	$CHCl_3$	*4.585*	23.5	20.7	
	p-Nitrobenzoyl-*d*-carvoxime	$CHCl_3$	*4.565*	22.5	17.3	
$C_{17}H_{19}NO_2$	Benzoyl-*d*-carvoxime	$CHCl_3$	*9.106*	18.5	26.6	(728); *cf.* (382)
		C_6H_6	*9.88*		11.6	(1812)
	Benzoyl-β-carvoxime	C_6H_6			75.3	(380)
$C_{17}H_{20}N_2O_2$	Carbanilido-*d*-carvoxime	$CHCl_3$	2.720	18	31.7	(728)
$C_{18}H_{21}NO_2$	Phenylacetyl-*d*-carvoxime	$CHCl_3$	*7.781*	22	40.6	(728)
		C_6H_6	10.05		24.5	(1812)
$C_{18}H_{21}NO_2$	*o*-Toluyl-*d*-carvoxime	$CHCl_3$	*9.19*	15.5	27.1	(728)
	m-Toluyl-*d*-carvoxime	$CHCl_3$	*10.02*	15.5	26.9	
	p-Toluyl-*d*-carvoxime	$CHCl_3$	*9.295*	15.5	23.4	
$C_{18}H_{22}N_2O_2$	Carbo-*o*-toluido-*d*-carvoxime	$CHCl_3$	*2.755*	18	27.4	(728)
	Carbo-*m*-toluido-*d*-carvoxime	$CHCl_3$	*2.740*	18	29.8	
	Carbo-*p*-toluido-*d*-carvoxime	$CHCl_3$	*2.711*	20	30.8	
$C_{19}H_{21}NO_2$	Cinnamoyl-*d*-carvoxime	C_6H_6	*10.59*	20	15.4	(1812)
$C_{19}H_{23}NO_2$	Dihydrocinnamoyl-*d*-carvoxime	C_6H_6	*10.00*	20	26.2	(1812)
$C_{20}H_{23}NO_2$	α-Methylcinnamoyl-*d*-carvoxime	C_6H_6	*10.04*	20	16.3	(1812)
	β-Methylcinnamoyl-*d*-carvoxime	C_6H_6	*9.94*	20	22.5	
$C_{20}H_{25}NO_2$	α-Methylhydrocinnamoyl-*d*-carvoxime	C_6H_6	*9.95*	20	23.9	(1812)
	β-Methylhydrocinnamoyl-*d*-carvoxime	C_6H_6	*9.88*	20	22.8	
$C_{24}H_{25}NO_2$	Diphenylacetyl-*d*-carvoxime	C_6H_6	*9.90*	20	17.6	(1812)
$C_{25}H_{25}NO_2$	α-Phenylcinnamoyl-*d*-carvoxime	C_6H_6	*10.03*	20	37.1	(1812)
	β-Phenylcinnamoyl-*d*-carvoxime	C_6H_6	*10.08*	20	26.4	
$C_{25}H_{27}NO_2$	α-Phenylhydroxycinnamoyl-*d*-carvoxime	C_6H_6	*9.99*	20	12.5	(1812)
	β-Phenylhydroxycinnamoyl-*d*-carvoxime	C_6H_6	*9.73*	20	20.1	
	Menthone and derivatives					
$C_{10}H_{16}O$	Δ^4-Menthenone	MeOH	*14.62*	18	−67.46	(2124)
	Δ^3-Menthenone			20	−78.04	(306)
$C_{10}H_{16}Br_2O$	Dibromomenthone	CCl_4	*3.05*		199.4	(104)
$C_{10}H_{18}O$	*d*-*p*-Menthone*	EtOH	*7.57*		30.20	(1121)
$C_{10}H_{18}O_2$	8-Hydroxymenthan-2-one†	EtOH	*18.5*	20	−18.5	(1101)
$C_{10}H_{19}NO$	*l*-Menthone oxime	EtOH	*10*	20	42.51	(101)
$C_{10}H_{19}NO$	*l*-Isomenthone oxime	EtOH	*24*	21	−52.25	(144.5)
$C_{10}H_{19}NO$	*d*-Isomenthone oxime	EtOH	*20*	20	−4.85	(101, 1491)
$C_{10}H_{20}ClNO$	*d*-Isomenthone oxime hydrochloride	EtOH	*10*		−24.48	(101)
$C_{10}H_{20}ClNO$	*l*-Menthone oxime hydrochloride	EtOH	*10*	20	61.16	(101)
$C_{17}H_{22}O_2$	Benzoylmenthone (enol form)	C_6H_6		20.5	32.11	(157)
$C_{17}H_{22}O$	Benzylidenementhone (form A)	EtOH	*6*		−186.1	(1395)
		$CHCl_3$	*6*		−185.8	
	(form B)	EtOH	*3*		−261.1	
		$CHCl_3$	*6*		−258.0	
$C_{17}H_{22}O$	Benzylidenementhone (form A)	EtOH	*6*		−185.83	(1394)
	(form B)	EtOH	*6*		−258.08	
$C_{17}H_{23}NO_2$	*l*-Menthone oxime benzoyl derivative	Et_2O	*9.89*		1.9	(2113)
$C_{17}H_{24}O$	Benzylmenthone	C_6H_6		23	28.4	(158)
$C_{18}H_{26}O$	Menthonylmethylphenylmethane‡	C_6H_6		19	95.27	(157)
$C_{18}H_{24}O_2$	Anisylidenementhone	$CHCl_3$	3.4		−278.43	(1395)
$C_{19}H_{28}O$	Menthonylphenylethylmethane	C_6H_6			−17.57	(156)
$C_{21}H_{32}O$	Menthonylisoamylphenylmethane	C_6H_6		20.5	13.75	(157)
$C_{23}H_{28}O$	Menthonyldiphenylmethane§ (isomeride (a))	C_6H_6			−158.5	(156)
	(isomeride (b))	C_6H_6			0	
$C_{24}H_{24}O$	Dibenzylidene-Δ^4-menthenone	$CHCl_3$	*2.92*	20	−58.41	(2124)
$C_{25}H_{30}O_2$	Menthonylmethylphenylmethane benzoate ‖	C_6H_6		20.5	145.7	(157)
$C_{29}H_{38}O_2$	Menthonylisoamylphenylmethane benzoate¶	C_6H_6	?	19.5	186.5	(157)

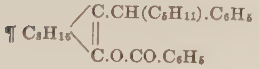
* 

$CH_3.CH\langle{}^{CH_2.CO}_{CH_2.CH_2}\rangle CH.CH(CH_3)_2$. † Dihydroxycarvone hydrate.

‡ 

$C_8H_{16}\langle{}^{CH.CH(CH_3).C_6H_5}_{CO}$. § $C_{10}H_{17}O.CH(C_6H_5)_2$. ‖ 

$C_8H_{16}\langle{}^{C.CH(CH_3).C_6H_5}_{C.O.CO.C_6H_5}$, derived from enolic isomeride of the ketone.

¶ 

$C_8H_{16}\langle{}^{C.CH(C_5H_{11}).C_6H_5}_{C.O.CO.C_6H_5}$, derived from enolic isomeride of the ketone.

Other ketones of the terpene series

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_9H_{14}O$	Camphenilone*	C_6H_6	*10*	19	−61.21	(1256)
$C_9H_{14}O$	Nopinone		0.983	18	18.48	(2127)
		C_6H_6	*12.36*	17	10.95	
		Et_2O	*7.15*	14	11.02	
		EtOH	*7*	18	38.04	
$C_{10}H_{14}O$	*d*-Verbenone		0.978_4^{20}	18	249.6	(154)
		EtOH	*9.04*	18	229.6	
		C_6H_6	*8.25*	18	245.7	
$C_{10}H_{14}O$	*l*-Verbenone		0.982^{15}		−146.6	(154)
$C_{10}H_{14}O$	Umbellulone		0.958^{20}		31.5	(1920)
$C_{10}H_{14}Br_2O$	Dibromodihydroumbellulone	$CHCl_3$	2.10		6.4	(1183)
$C_{10}H_{15}BrO$	Bromodihydroumbellulone	$CHCl_3$	1.67		−70.1	(1183)
$C_{10}H_{16}O$	Dihydro-*d*-verbenone		0.966^{18}	18	52.19	(154)
$C_{10}H_{16}O$	β-Dihydroumbellulone		0.928^{20}		−33.08	(1920)
$C_{10}H_{16}O$	Carvotanacetone (λ = 5780)		0.937	18	59.8	(2063)
$C_{10}H_{16}O$	Pulegone†		0.9293	23	25.35	(78)
			0.9323	20	22.89	(105)
$C_{10}H_{16}N_2O_4$	Pulegone nitrosite	$CHCl_3$		23	23.13	(714)
$C_{11}H_{15}NO$	Cyanocarone	EtOH	0.924	20	297	(328)
$C_{11}H_{17}NO$	Isopulegone oxime	MeOH	*6.43*	22	−25.83	(2121)

CARBOXYLIC ACIDS

MONOCARBOXYLIC ACIDS‡

Campholytic, campholenic and fencholenic acids (mainly 5-atom rings)

$C_9H_{14}O_2$	Campholytic acid§		1.017_4^{15}	10	−5	(2101.5); *cf.* (1527, 2104)
$C_9H_{15}IO_2$	*d*-Iododihydrocampholytic acid	CS_2	4.2	28	99.4	(1527)
		CS_2	3.2	28	97.8	
		CS_2	2.9	23	92.9	
$C_9H_{16}O_2$	Dihydrocampholytic acid		0.9915_4^{20}	25	33.7	(1527)
$C_9H_{17}NO$	Dihydrocampholytic amide	ligroin	3.4	22	20.6	(1527)
$C_{10}H_{15}N$	α-Fencholenic nitrile‖ (IID)		$0.9136_{15.6}^{15.6}$	15.6	28.98	(334.5)
	β-Fencholenic nitrile‖ (IID)		$0.9203_{15.6}^{15.6}$	15.6	43.66	
$C_{10}H_{25}N$	Campholenic nitrile			23	45	(806)
		EtOH	4.64	23	53.9	
$C_{10}H_{15}O_5SNH_4$	Ammonium hydrogen sulfocampholene-carboxylate¶	H_2O	1.66		−6.9	(836)
$C_{10}H_{16}O_2$	α-Campholenic acid**			18	10.93	(1136)
$C_{10}H_{16}O_2$	β-Fencholenic acid††(IID)	EtOH			19.64	(1922)
	γ-Fencholenic acid††		1.0087^{20}	20	52.5	(1923)
$C_{10}H_{17}NO$	α-Campholenic amide	EtOH	*5*	16	−4.33	(1136)
$C_{10}H_{17}NO$	Pulegenic amide‡‡	MeOH	*21.26*	18	29.05	(2129)
$C_{10}H_{18}O_2$	α-Dihydrocampholenic acid		$0.9773_4^{20.5}$	15	24.98	(1136)
$C_{10}H_{18}O_2$	Dihydrofencholenic acid		0.9742_4^{15}	15	4.10	(1919)
$C_{10}H_{19}NO$	α-Dihydrocampholenic amide	96% EtOH	*5*	16	26.43	(1136)
$C_{10}H_{19}NO$	Dihydropulegenic amide	MeOH	*16.78*	20	4.85	(2129)
$C_{11}H_{18}O_2$	Ethyl campholytate		0.962_4^{15}	10	5.04	(2101.5)
$C_{11}H_{18}O_2$	Ethyl γ-lauronolate		0.9514_4^{20}	26	56.6	(1520)
$C_{11}H_{20}O_2$	Methyl dihydrofencholenate		0.9295^{22}	22	3.0	(1919)
$C_{12}H_{19}N$	α-Ethylcampholenic nitrile	EtOH	11.8	13	70.33	(1281)
$C_{12}H_{22}O_2$	Ethyl dihydrofencholenate		0.9129^{20}	20	3.50	(1919)
$C_{12}H_{22}O_2$	Ethyl α-dihydrocampholenate		$0.9276_4^{14.8}$	15.5	21.82	(1136)
$C_{13}H_{21}N$	Propylcampholenic nitrile	EtOH	22.6	16	46.52	(1281)

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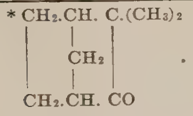
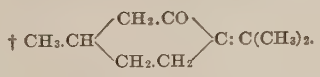
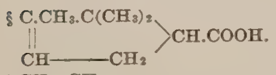
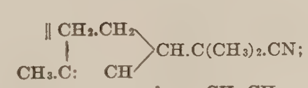
‡ For hydroxy derivatives, *see* p. 417; for amino derivatives, *see* p. 420.

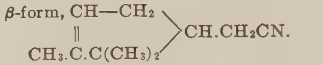


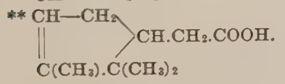


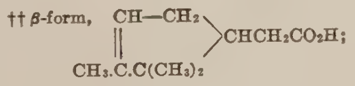
¶ HO.CO.C_9H_{14}.SO_2.ONH_4.

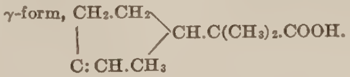


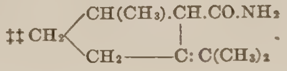




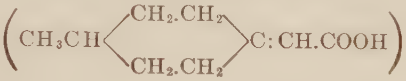
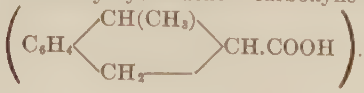


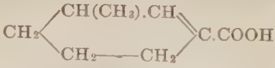


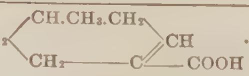


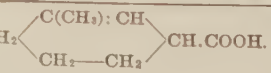


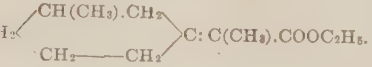
Campholytic, campholenic and fencholenic acids (mainly 5-atom rings).—(Continued)

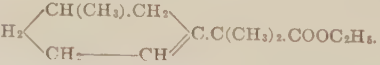
Formula	Name	Solvent	d, C % or	t, °C	[α]$_D$	Lit.
$C_{13}H_{19}N$	Allylcampholenic nitrile	EtOH	13.3	14	28.90	(1281)
		EtOH	21.0		28.66	
$C_{17}H_{21}N$	Benzylcampholenic nitrile	EtOH	18.7	17	54.07	(1281)
		EtOH	15.4	17	44.40	
	Tetrahydrotoluic acids and homologues (6-atom rings, including derivatives of cyclohexylideneacetic acids)					
$C_8H_{12}Br_2O_2$	*d*-3, 4-Dibromo-1-methylcyclohexane-3-carboxylic acid	AcOEt	3.101		28.5	(1312)
$C_8H_{12}Br_2O_2$	*d*-3, 4-Dibromo-1-methylcyclohexane-4-carboxylic acid	AcOEt	4.682		102.2	(288)
$C_8H_{12}O_2$	*d*-1-Methyl-Δ²-cyclohexene-3-carboxylic acid*	AcOEt	2.609		40.1	(1312)
$C_8H_{12}O_2$	*d*-1-Methyl-Δ³-cyclohexene-4-carboxylic acid†	AcOEt	5.035		150.1	(288); *cf.* (1048)
$C_8H_{12}O_2$	*d*-1-Methyl-Δ⁵-cyclohexene-3-carboxylic acid	AcOEt	5.044	16	33.1	(1600)
$C_8H_{12}O_2$	*l*-1-Methyl-Δ¹-cyclohexene-3-carboxylic acid‡				−49.7	(840)
$C_8H_{12}O_2$	*d*-1-Methyl-Δ⁶-cyclohexene-3-carboxylic acid				108	(840)
$C_9H_{14}O_2$	*l*-1-Methylcyclohexylidene-4-acetic acid 	EtOH (abs.)	0.727		−81.1	(1601, 1601.5)
		EtOH (abs.)	1.593		−77.8	
		MeOH	0.551		−74.6	
		Et_2O	0.806		−74.4	
		$CH_2(OCH_3)_2$	0.7506		−74.6	
	d-1-Methylcyclohexylidene-4-acetic acid	EtOH (abs.)	0.725		81.4	(1601, 1601.5)
		EtOH (abs.)	1.475		78.0	
		MeOH	0.742		75.5	
		Et_2O	0.737		75.3	
		$CH_2(OCH_3)_2$	0.718		75.5	
$C_{10}H_{16}O_2$	Ethyl *d*-1-methyl-Δ²-cyclohexene-3-carboxylate	AcOEt	3.074		32.5	(1312)
	Ethyl *l*-1-methyl-Δ²-cyclohexene-3-carboxylate	AcOEt	4.119		−28.9	
$C_{10}H_{16}O_2$	Ethyl *d*-1-methyl-Δ³-cyclohexene-4-carboxylate	AcOEt	4.819	20	122.3	(288); *cf.* (1048)
$C_{10}H_{16}O_2$	Ethyl *d*-1-methyl-Δ⁵-cyclohexene-3-carboxylate	AcOEt	4.760	16.5	30.5	(1600)
$C_{12}H_{20}O_2$	Ethyl 1-methylcyclohexylidene-3-α-propionate§		0.9487_4^{16}		48.41	(2236)
$C_{12}H_{22}O_2$	Ethyl 1-methyl-Δ³-cyclohexenyl-3-α-isobutyrate‖		0.9460_4^{18}		45.59	(2236)
	Other cyclic monocarboxylic acids					
$C_{10}H_9NO_4$	5-Nitrohydrindene-2-carboxylic acid	H_2O	0.405	20	29.6	(1425)
		H_2O	0.405	20	36.4	
$C_{11}H_{12}O_2$	*d*-3-Methylhydrindene-2-carboxylic acid 	EtOH	1.88		67.66	(1513)
		C_6H_6	1.23		76.86	
		PhMe	0.979		89.33	
	Barium salt	H_2O	2.06		24.02	(1513)
$C_{12}H_{14}O_2$	Methyl *d*-3-methylhydrindene-2-carboxylate	EtOH	1.07		63.22	(1513)
$C_{18}H_{32}O_2$	Chaulmoogric acid	$CHCl_3$	3.89		56	(1696)
		C_6H_6	10	20	61.8	(1195)
$C_{18}H_{33}NO$	Chaulmoogramide	$CHCl_3$	4.3	27	57.3	(1696)

* 

† 

‡ 

§ 

‖ 

Other cyclic monocarboxylic acids.—(Continued)

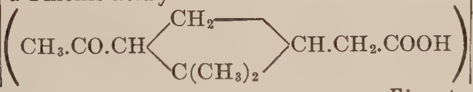
Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{19}H_{34}O_2$	Methyl chaulmoograte	$CHCl_3$	5	15	50	(1696)
			0.9119^{25}_{25}	15	50.5	
$C_{20}H_{36}O_2$	Ethyl chaulmoograte		0.9079^{15}_{16}	20	50.7	(1696)

OXY AND HYDROXY ACIDS

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_4H_5O_3K$	Potassium *d*-α-methylglycidate*	H_2O	*9.96*	20	−17.57	(1047)
$C_9H_{14}N_2O_2$	Nitrosoaminodihydrocampholic anhydride†	EtOH	2.5	25	−83.3	(1527)
$C_9H_{14}O_2$	*d-trans*-Hydroxydihydrocampholytic lactone	EtOH	10	27	121.9	(1527)
$C_9H_{16}O_3$	*l-trans*-Hydroxydihydrocampholytic acid	H_2O	*1.45*		−70.04	(1522)
$C_9H_{16}O_3$	*d-trans*-Hydroxydihydrocampholytic acid‡	AcOEt	8		70.1	(1527)
	d-cis-Hydroxydihydrocampholytic acid	EtOH	8.2		50.8	
$C_9H_{17}NO_2$	Aminodihydrocampholytic acid	H_2O	5	25	54.7	(1528)
$C_9H_{18}ClNO_2$	Aminodihydrocampholytic acid hydrochloride	H_2O	10	26	41.3§	(1528)
$C_{10}H_{14}O_4$	*d*-Cineolic anhydride	C_6H_6	*8.20*	20	45.37	(1840)
$C_{10}H_{16}O_2$	*l*-Dihydrocarvenolide (dihydropulegenolide, lactone of dihydrocarvenolic acid)	MeOH	*21.8*	18	−57.57	(2129)
		MeOH	*22.34*	19	−56.85	
$C_{10}H_{16}O_3$	Nopinic acid‖	Et_2O	*16.1*	17	−15.64	(2127)
$C_{10}H_{16}O_3$	*dl*-Hydroxyfenchenic acid¶	Et_2O	*7.57*	13	−62.98	(2130)
$C_{10}H_{16}O_3$	Pulegenolic acid (oxidation product)	MeOH	*21*		−18.44	(2129)
	Pulegenic oxylactone (oxidation product)	MeOH	*17.45*	20	−10.27	
$C_{10}H_{16}O_5$	Ascaridolic acid** (1, 4-cineolic acid)	$CHCl_3$	8.22	24	13.93	(1493)
$C_{10}H_{16}O_5$	*l*-Cineolic acid††	H_2O	*7.33*	20	−19.10	(1840)
$C_{10}H_{17}NO$	Hydroxydihydrofenchonitrile‡‡		0.9792^{15}_{15}	18	−8	(1359)
$C_{10}H_{18}O_3$	Dihydrocarvenolic acid§§	Et_2O	*12.298*	17	9.43	(2129)
$C_{11}H_{20}O_3$	Ethyl 1-methylcyclohexan-3-ol-3-acetate‖‖		0.9984^{19}_{4}		−1.53	(2236)

KETONIC ACIDS

Four-atom rings

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{16}O_3$	*l*-Pinonic acid *d*-Pinonic acid 	$CHCl_3$ $CHCl_3$		22 25	−90.5 89.0	(83)

Five-atom rings

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_8H_{12}O_3$	Methyl 4-methyl-2-cyclopentanone-carboxylate		1.07	15	91.11	(811)
$C_9H_{14}O_3$	Umbellonic acid¶¶	$CHCl_3$	2.14		377.6	(2044)
$C_9H_{14}O_3$	Ethyl 4-methyl-2-cyclopentanonecarboxylate		1.05	15	78.40	(811)
$C_{10}H_{16}O_3$	Propyl 4-methyl-2-cyclopentanonecarboxylate		1.029	15	64.75	(811)
$C_{11}H_{18}O_3$	Isobutyl 4-methyl-2-cyclopentanonecarboxylate		0.956^{20}_{20}	15	66.15	(811)

Six-atom rings (including hydrindone)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_8H_{12}O_3$	*d*-1-Methylcyclohexan-3-one-4-carboxylic acid	EtOH	2.40	17	97.2	(709)
$C_{10}H_{16}O_3$	Ethyl *d*-1-methylcyclohexan-3-one-4-carboxylate	EtOH	2.17	17.5	84.2	(709)
$C_{11}H_{17}NO$	Menthonecarboxylic anhydramide	EtOH	1.01	17	66.6	(326)

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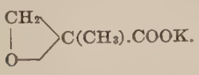
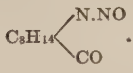
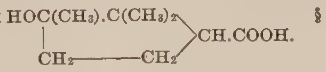
* 

† 

‡ 

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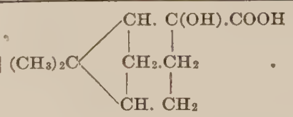
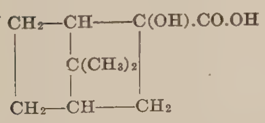
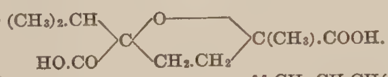
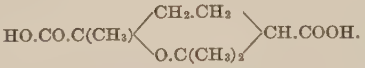
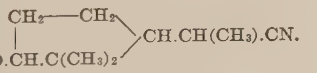
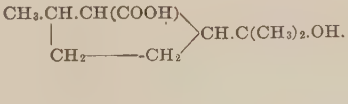
‖ 

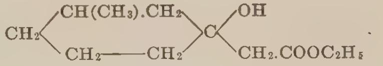
¶ 

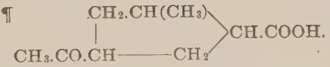
** 

†† 

‡‡ 

§§ 

‖‖ 

¶¶ 

Six-atom rings (including hydrindone).—(Continued)

Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{11}H_{18}O_3$	Carvomenthonecarboxylic acid*	AcOEt	1.53	22	−4.3	(1170)
$C_{11}H_{18}O_3$	Menthonecarboxylic acid†	EtOH	1		−23.0	(326)
$C_{12}H_{18}O_2$	Pulegoneacetic anhydride, enolic (for pulegolacetic anhydride, *see* p. 428)	EtOH	7.57	20	71.61	(2078)
$C_{12}H_{18}O_5$	*d*-Isomenthonedicarboxylic acid‡	EtOH	1.728	17	124.4	(709)
$C_{12}H_{19}NO$	Pulegoneacetamide anhydride	EtOH	1.59	20	65.99	(2078)
$C_{12}H_{20}O_3$	Pulegoneacetic acid§	EtOH	1.084	20	−3.2	(2078)
$C_{13}H_{22}O_3$	Methyl pulegoneacetate	MeOH	3.29	20	−6.88	(2078)
$C_{14}H_{20}O_4$	Pulegonemalonic anhydride methyl ester	98% MeOH	3.61	20	26.6	(2078)
$C_{14}H_{24}O_3$	Ethyl pulegoneacetate	EtOH	3.61	20	−1.13	(2078)
$C_{15}H_{24}O_5$	Dimethyl pulegonemalonate	MeOH	3.15	20	−8.79	(2078)
$C_{17}H_{28}O_5$	Diethyl pulegonemalonate	EtOH	4.58	20	−3.27	(2078)
$C_{17}H_{12}O_3$	Dihydroisocumarinhydrindone-2, 3-spirane‖	C_6H_6	*1.52*	20	−65	(1206)
$C_{17}H_{13}ClO_3$	*d*-*β*-Chloro-*β*-(benzyl-*o*-carboxylic acid)-hydrindone¶	AcOH	*2.92*	20	130	(1206)
	DICARBOXYLIC ACIDS					
	Three-atom rings					
$C_6H_6O_4$	3-Methylcyclopropene-1, 2-dicarboxylic acid	H_2O			179.8	(449.5)
	Four-atom rings					
$C_{11}H_{18}O_4$	Dimethyl pinate**		1.0582^{20}	20	13.9	(1924)
			1.0548	20	9	(1928)
$C_{24}H_{20}ClNO_2$	*d*-*α*-Truxillanilidyl chloride	Me_2CO	3.78	20	12.42	(1987)
	l-*γ*-Truxillanildyl chloride (impure)	Me_2CO	2.73	19	−9.53	
$C_{24}H_{21}NO_3$	*l*-*α*-Truxillanilidic acid††	Me_2CO	5.0	19	−23.0	(1987)
	d-*γ*-Truxillanilidic acid	Me_2CO	3.15	21	48.73	
$C_{24}H_{22}N_2O_2$	*l*-*α*-Truxillanilidic amide	Me_2CO	1.35	20	−28.8	(1987)
	d-*γ*-Truxillanilidic amide	Me_2CO	1.56	19	35.6	(1987)
$C_{25}H_{23}NO_3$	Methyl *l*-*α*-truxillanilidate	Me_2CO	3.35	20	−22.4	(1987)
	Methyl *l*-*γ*-truxillanilidate	Me_2CO	5.01	18	−38.55	
$C_{25}H_{25}NO_3$	Ethyl *d*-*α*-truxillanilidate	Me_2CO	4.48	20	18.75	(1987)
	Ethyl *d*-*γ*-truxillanilidate	Me_2CO	2.461	18	25.19	
	Five-atom rings					
$C_7H_{10}O_4$	*d*-*trans*-Cyclopentane-1, 2-dicarboxylic acid	H_2O	0.876		87.6	(733)
$C_7H_{10}O_4$	*d*-*trans*-Cyclopentane-1, 3-dicarboxylic acid	H_2O	5.040		5.86	(1604)
$C_{11}H_{18}O_4$	Diethyl *d*-*trans*-cyclopentane-1, 3-dicarboxylate	EtOH	6.291		5.01	(1604)
$C_8H_{12}O_4$	Umbellaric acid‡‡	$CHCl_3$	2.04		−89.7	(2044)
$C_{10}H_{16}O_4$	Camphenecamphoric acid§§	EtOH	*20.9*	16	−1.166	(2118)
	Six-atom rings					
$C_{12}H_{16}O_4$	2-Methyl-5-isopropenyl-Δ^2-tetrahydroisophthalic acid	EtOH	1.59	19.5	−172.8	(1170)
$C_{12}H_{18}O_4$	2-Methyl-5-isopropenylhexahydroisophthalic acid	EtOH	0.93	17	−16.6	(1170)
$C_{14}H_{24}O_4$	Ethyl 1-methylcyclohexane-3-malonate				−58	(529.5)
	TRICARBOXYLIC ACIDS					
$C_8H_{10}O_6$	*dl*-*trans*-Cyclopentane-1, 2, 3-tricarboxylic acid	H_2O	1.007		72.4	(1603)
$C_{15}H_{24}O_6$	Trimethyl 1-carboxy-3-methylcyclohexanylsuccinate		1.140^{20}	20	−27.8	(1934)

AMINES

MONOAMINES

Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{19}N$	*d*-*α*-Camphylamine‖‖		0.8688	20	3.83	(1681)

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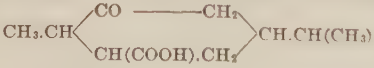

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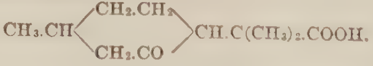

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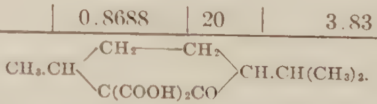

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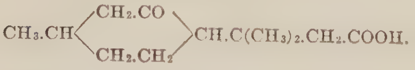

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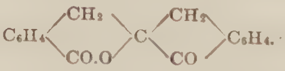

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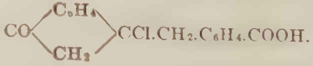

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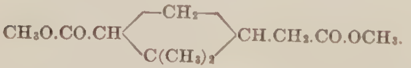

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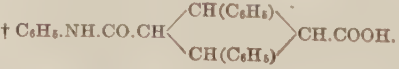

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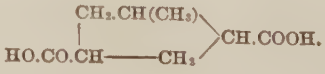

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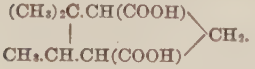

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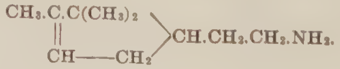

DIAMINES

Sparteine, its derivatives and isomers

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{15}H_{24}N_2$	Spartyrine	Et_2O	27.74	18.5	−25.96	(2189)
$C_{15}H_{24}N_2O$	Oxysparteine	EtOH	18.12	18	−10.04	(2189)
$C_{15}H_{26}N_2$	Sparteine*	EtOH	12.5	15	−16.4	(1473)
			1.0196^{20}_{0}	20	−5.4	
$C_{15}H_{26}N_2$	Isosparteine†	EtOH	8.892		−23.99	(1471)
		EtOH	10.00		−25	(1473)
$C_{15}H_{27}IN_2$	Sparteine hydroiodide	MeOH	8.136	15	−11	(1473)
		H_2O	2.126	18	−14.1	
$C_{15}H_{27}IN_2$	Isosparteine hydroiodide	MeOH	6.418	?	−33.5	(1473)
$C_{15}H_{28}I_2N_2$	Sparteine dihydroiodide	H_2O	6.284	?	−16.2	(1473)
$C_{16}H_{25}N$	Methylhemisparteilene	EtOH	3.938	?	168.4	(1473); *cf.* (1468)
		EtOH	3.912	?	158.4	
		EtOH	5.780	?	156.5	
$C_{16}H_{28}N_2$	α-Methylsparteine	EtOH	11.548		−55.4	(1473); *cf.* (1469)
	β-Methylsparteine	EtOH	5.68	?	9.9	
$C_{16}H_{28}N_2$	Methylisosparteine	EtOH	9.75	?	23.6	(1473)
		EtOH	9.752		23.58	(1471)
$C_{16}H_{29}IN_2$	Isosparteine methiodide	H_2O			−16.8	(1470)
$C_{16}H_{29}IN_2$	Sparteine α-methiodide	H_2O	8.5	15	−22.7	(1473)
	Sparteine α′-methiodide	H_2O	6.434	?	−47.7	
$C_{16}H_{29}IN_2$	α-Isosparteine methiodide	H_2O	1.268		−18.4	(1473)
		MeOH	6.350		−16.8	(1471, 1473)
	α′-Isosparteine methiodide	MeOH	6.400		−33.34	(1473); *cf.* (1471)
$C_{16}H_{29}IN_2.2H_2O$	β-Methylsparteine monohydroiodide	H_2O	3.722		−32.2	(1473)
		MeOH	6.775		−28.2	
$C_{16}H_{30}Cl_2N_2$	Isosparteine methochloride hydrochloride	H_2O	3.80	?	−19.7	(1473)
$C_{16}H_{30}I_2N_2$	α-Methylsparteine dihydroiodide	H_2O	3.848		−37.2	(1473)
		H_2O	1.952		−38.3	
	β-Methylsparteine dihydroiodide	MeOH	4.288	?	−13.5	(1473)
$C_{16}H_{30}I_2N_2$	Sparteine α-methiodide hydroiodide	H_2O	6.708	15	−17.1	(1473)
	Sparteine α′-methiodide hydroiodide	H_2O	2.017	?	−39.6	
$C_{16}H_{30}I_2N_2$	α-Isosparteine methiodide hydroiodide	H_2O	8.640		12.5	(1471)
		H_2O	1.938		17.88	(1471, 1473)
$C_{16}H_{30}N_2O_4S$	Isosparteine methosulfate	H_2O	*10*		−13.65	(2061)
$C_{16}H_{30}N_2O_4S.9H_2O$	Isosparteine methosulfate	H_2O	10.13		−13.6	(1473)
$C_{16}H_{39}ClN_2.2H_2O$	α-Methylsparteine dihydrochloride	H_2O	2.6525		−56.5	(1473)
$C_{17}H_{31}IN_2$	Sparteine α-ethiodide	H_2O	3.898		−24.4	(1473)
		MeOH	2.524		−25.4	
$C_{17}H_{31}IN_2$	α-Methyl sparteine methiodide	MeOH	4.21		−95.1	(1473)
$C_{17}H_{32}I_2N_2$	Sparteine α-ethiodide hydroiodide	H_2O	4.535		−16.9	(1473)
		MeOH	5.724		−16.9	
$C_{18}H_{34}I_2N_2$	Methylisoparteine dimethiodide	H_2O	6.464		21.35	(1471, 1473)
$C_{19}H_{36}I_2N_2$	Dimethylsparteine dimethiodide	H_2O	1.1190		−12.5	(1473)
	AMINO ACIDS					
	Pilocarpine and related compounds including pilosine (IIC₂B), anhydropilosine and pilosinine					
$C_8H_{11}NO_4$	Pilopinic acid	EtOH	5.9	16	−13.6	(1015)
$C_9H_{12}N_2O_2$	Pilosinine‡ (after 5 days)	H_2O	4.062		3.1§	(1750)
	(after warming)	KOH	3.941		−5.8	
$C_9H_{13}N_3O_5$	Pilosinine nitrate	H_2O	8.412		4.3	(1750)
$C_{10}H_{15}BrN_2O_4$	Bromocarpinic acid	EtOH	*6.12*		−90.5	(1647)
$C_{11}H_{14}Br_2N_2O_2$	Dibromopilocarpine	EtOH	3.44	15	43.6	(1015)
$C_{11}H_{14}Br_2N_2O_4$	Dibromoisopilocarpinic acid	EtOH	6.54	16	24.4	(1015)

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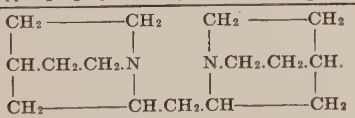
*



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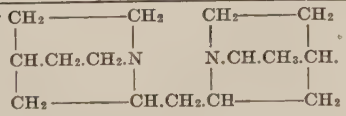

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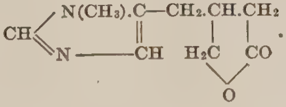


§ Mutarotation.

Pilocarpine and related compounds including pilosine (IIC_2B), anhydropilosine and pilosinine.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{11}H_{14}N_2O_4$	Isopilocarpinolactone	EtOH	4.05	16	−51.9	(1015)
$C_{16}H_{16}N_2O_2$	Anhydropilosine*	90% EtOH	3.571		66.2	(1750)
	(after boiling)	KOH	3.142		−132.7	(1750)
$C_{16}H_{18}N_2O_3$	Pilosine†	$CHCl_3$	1.168		40.2	(1750)
		EtOH	0.827		39.9	
$C_{18}H_{18}N_2O_6$	Anhydropilosine oxalate	H_2O	4.093		−17.8	(1750)
$C_{20}H_{24}N_2O_9$	Pilosine hydrogen *d*-tartrate	H_2O	3.838		24.2	(1750)
$C_{32}H_{34}N_4O_8S$	Anhydropilosine sulfate	H_2O	4.064		−17.6	(1750)
$C_{32}H_{38}N_4O_{10}S$	Pilosine sulfate	H_2O	4.454		21.0	(1750)

Other cyclic amino acids (nitrogen in ring)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_9H_{15}NO_2$	Meroquinenic acid‡ (merochinen)	H_2O	*10*	20	27.58	(1117)
$C_{10}H_{16}N_2$	Methylmeroquinenic nitrile§	H_2O	*0.971*	20	17.11	(1754)

IICB. The Molecule Contains Two or More Asymmetric Atoms Attached Respectively to Two and Three Other Carbon Atoms

HYDROCARBONS AND HALIDES

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_6H_{11}I$	1-Methyl-3-iodo-cyclopentane				−2.50	(306)

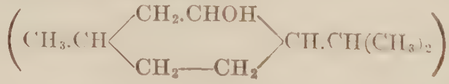
ALCOHOLS

MONOHYDRIC ALCOHOLS

Cyclic alcohols not derived directly from terpenes

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_7H_{14}O$	1, 3-Methylcyclohexanol			20	4.16	(306)
$C_6H_{12}O$	1, 3-Methylcyclopentanol				−4.89	
$C_{10}H_{18}O$	1, 3-Methylcyclohexanyl allyl ether		0.8738^{15}_{4}		−14.33	(814)
$C_{10}H_{20}O$	1-Methyl-4-propyl-3-cyclohexanol		0.8976^{14}_{4}	19	−18	(816)
$C_{11}H_{22}O$	1-Methyl-4-isobutyl-3-cyclohexanol	EtOH			−70.37	(816)
	1-Methyl-4-isobutyl-3-cyclohexanol (liquid isomeride)				−18.01	
$C_{12}H_{24}O$	1, 2, 2-Trimethyl-5-isopropylcyclohexan-6-ol				3.23	(800)
$C_{14}H_{20}O$	4-Benzyl-1-methyl-3-cyclohexanol	EtOH			−53.35	(817)
$C_{15}H_{20}O$	4-Anisyl-1-methyl-3-cyclohexanol	EtOH	2.05		6.50	(815)
$C_{19}H_{30}O$	2-Methyl-1, 1, 5, 5-tetraallylcyclohexan-6-ol		0.9613	17	−9.25	(800)
$C_{21}H_{26}O$	2, 4-Dibenzyl-1-methyl-3-cyclohexanol	EtOH			−10.1	(817)

Terpene alcohols including menthol, homologues and derivatives

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_9H_{16}O$	α-Nopinol‖	Et_2O	*12.53*	18	−5.32	(2127)
	β-Nopinol	Et_2O	*13.15*	17	15.03	
$C_{10}H_{16}O$	*d*-Verbenol¶		0.9722^{18}	18	132.3	(154)
$C_{10}H_{16}O$	Pinocarveol**	Et_2O	*12.7*	20	−52.45	(2115)
$C_{10}H_{16}O$	Dihydroumbellulol††		0.931^{20}		29.6	(1920)
$C_{10}H_{18}O$	Dihydrocarveol‡‡		0.9204^{20}_{4}		33.86	(299)
$C_{10}H_{20}O$	Carvomenthol (λ = 5780)		0.908	20	−24.7	(2063); *cf.* (1128)
	(λ = 4359)		0.908	20	−47.4	
$C_{10}H_{20}O$	Menthol (3-menthenol)	PhMe	5.39	20	−46.81	(306)
			0.8888^{45}_{45}	47	−49.88	(1599)
		CCl_4	10.241	17.5	−46.58	(2100); *cf.* (50, 101, 1048.5, 1570.5, 1589.5, 1868)
		CCl_4	0.529	17.5	−44.38	
		Me_2CO	10.125	17.5	−47.94	
		Me_2CO	0.475	17.5	−47.40	
		AcOEt	9.823	17.5	−48.14	
		AcOEt	0.473	17.5	−48.6	
		C_6H_6	10.10	17.5	−46.02	
		C_6H_6	2.91	17.5	−45.2	
		EtOH	9.63	17.5	−50.58	
		EtOH	0.463	17.5	−50.8	

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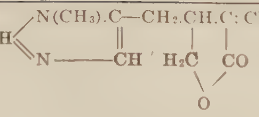
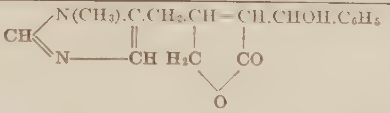
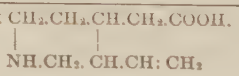
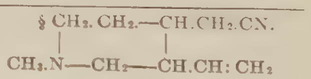
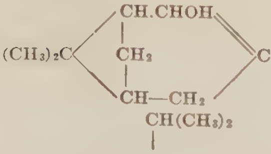
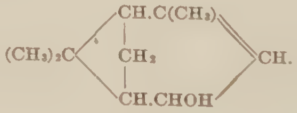
* 

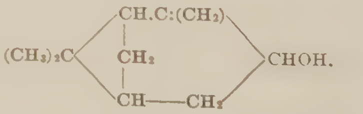
† 

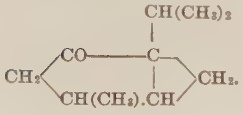
‡ 
$$\underset{NH.CH_3}{CH_2}.CH_2.\underset{CH.CH:CH_2}{CH}.CH_2.COOH.$$

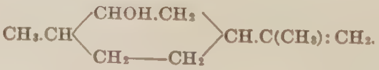
§ 
$$\begin{array}{l} CH_2.CH_2.—CH.CH_2.CN. \\ CH_3.N—CH_2—CH.CH:CH_2 \end{array}$$

‖  for homonopinol, *see* p. 412.

¶ 

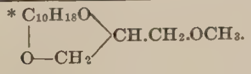
** 

†† 

‡‡ 

Terpene alcohols including menthol, homologues and derivatives.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{20}O$	Menthol.—(*Continued*)	EtOH (abs.)	5.03		−49.44	(1630)
	d-Neomenthol		0.90		19.69	(1630)
$C_{15}H_{26}O$	Selineol		0.9627	20	54.8	(1932)
	Ethers of menthol					
$C_{11}H_{21}ClO$	*l*-Menthyl chloromethyl ether	$CHCl_3$	6.78	21	−172.57	(2137)
$C_{13}H_{24}O$	*l*-Menthyl allyl ether		0.8763_4^{19}		−98.50	(814)
$C_{14}H_{26}O_3$	*l*-Menthylideneglycerol methyl ether*	80% EtOH	2.068	20	−21.2	(974)
$C_{21}H_{40}O_2$	Di-*l*-menthylmethylal	EtOH	0.8	24	−77.94	(2137)
	Esters of menthol, allomenthol and carvomenthol					
$C_{11}H_{21}NOS$	*l*-Menthyl xanthamide ($C_{10}H_{19}O.CS.NH_2$)	PhMe	4.99		−115.9	(299)
		C_6H_6	4.88		−120.78	
		EtOH	4.338		−113.17	
		AcOEt	4.89		−110.99	
		$PhNMe_2$	4.91		−100.82	
$C_{11}H_{21}NO_2$	*l*-Menthyl carbamate ($C_{10}H_{19}O.CO.NH_2$)	$CHCl_3$	*0.58*	21	−85.11	(50)
$C_{12}H_{21}BrO_2$	*l*-Menthyl bromoacetate	$CHCl_3$	2.5	20	−63.20	(910)
		$CHCl_3$	5	20	−62.64	
$C_{12}H_{21}ClO_2$	*l*-Menthyl chloroacetate	MeOH	*10.00*	20	−78.00	(636)
$C_{12}H_{22}O_2$	Carvomenthyl acetate (λ = 5780)		0.928	20	−27.6	(2063)
$C_{13}H_{20}BrNO_2$	*l*-Menthyl bromocyanoacetate	C_6H_6	1.62		−32.9†	(227)
$C_{13}H_{21}NO_2$	*l*-Menthyl cyanoacetate	C_6H_6	2.00		−81.15	(227)
$C_{13}H_{22}O_3$	*l*-Menthyl pyruvate		0.9917	11.5	−181.7	(343)
		$CHCl_3$	2.5	20	−82.0	
		$CHCl_3$	5.0	20	−83.4	
$C_{13}H_{23}BrO_2$	*l*-Menthyl α-bromopropionate	$CHCl_3$	2.5	20	−57.14	(1810)
		$CHCl_3$	5.0	20	−57.05	
$C_{14}H_{20}O_4$	*l*-Menthyl hydrogen acetylenedicarboxylate	$CHCl_3$	2.0		−67.75	(908)
		Me_2CO	2.0		−68.75	
$C_{14}H_{22}O_4$	*l*-Menthyl hydrogen fumarate	$CHCl_3$	2.0		−71.25	(908)
		Me_2CO	2.0		−69.25	
$C_{14}H_{24}O_2$	*l*-Menthyl trimethylenecarboxylate	EtOH	*9.54*	20	−68.53	(1810)
$C_{14}H_{24}O_2$	*l*-Menthyl crotonate	EtOH	*8.951*	20	−90.67	(1810)
		C_6H_6	*9.86*	20	−91.06	(1821)
$C_{14}H_{24}O_2$	*l*-Menthyl methacrylate	C_6H_6	*10.04*	20	−91.76	(1821)
$C_{14}H_{24}O_2$	*l*-Menthyl trimethylenecarboxylate	EtOH	*9.54*	20	−68.53	(1810)
$C_{14}H_{24}O_3$	*l*-Menthyl acetoacetate (const.)	EtOH	*1.5*		−68.5	(1171)
	(const.)	AcOEt	*1.5*		−59.8	
	(final)	$CHCl_3$			−70.7†	
	(final)	C_6H_6			−68.4†	
		$CHCl_3$	2.5	20	−67.04	(908); *cf.* (346, 1811)
$C_{14}H_{24}O_4$	*l*-Menthyl hydrogen succinate	Me_2CO	2.0		−65.5	(908)
		$CHCl_3$	2.0		−66.0	
		$CHCl_3$	5		−64.00	(1630)
		C_6H_6	1.4		−57.02	
$C_{14}H_{25}BrO_2$	*l*-Menthyl α-bromobutyrate	$CHCl_3$	2.5	20	−53.58	(293.5)
		$CHCl_3$	5.0	20	−53.49	
$C_{14}H_{26}O_2$	*l*-Menthyl isobutyrate	C_6H_6	*10.05*	20	−72.05	(1821)
	l-Menthyl butyrate	C_6H_6	*9.99*	20	−70.56	
					−69.52	(1810); *cf.* (294)
		EtOH	*9.04*		−72.91	
$C_{14}H_{26}O_3$	*l*-Menthyl *dl*-α-hydroxybutyrate	EtOH	4.699	20	−70.4	(1347)
	l-Menthyl *dl*-β-hydroxybutyrate		0.9859	20	−62.7	
		EtOH	5.082	20	−65.8	
$C_{15}H_{26}O_2$	*l*-Menthyl tetramethylenecarboxylate	EtOH	*9.180*	20	−69.09	(1810)
$C_{15}H_{26}O_2$	*l*-Menthyl-$\Delta^{1,2}$-pentenoate	EtOH	*9.250*	20	−74.41	(1810)
	l-Menthyl-$\Delta^{2,3}$-pentenoate	EtOH	*9.069*	20	−72.51	
	l-Menthyl-$\Delta^{3,4}$-pentenoate	EtOH	*9.006*	20	−67.32	
$C_{15}H_{26}O_2$	*l*-Menthyl tetramethylenecarboxylate	EtOH	*9.18*	20	−69.09	(1810)
$C_{15}H_{26}O_2$	*l*-Menthyl α-methylcrotonate	C_6H_6	*9.89*	20	−84.38	(1821)
	l-Menthyl β-methylcrotonate	C_6H_6	*10.01*	20	−88.60	

* 

$C_{10}H_{18}O{-}CH_2{>}CH.CH_2.OCH_3$. † Mutarotation.

Esters of menthol, allomenthol and carvomenthol.—(*Continued*)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{15}H_{26}O_3$	*l*-Menthyl methylacetoacetate	C_6H_6	*9.88*	20	−63.6	(1811)
$C_{15}H_{26}O_3$	*l*-Menthyl levulinate	$CHCl_3$	2.5	20	−67.6	(908)
		$CHCl_3$	5.0	20	−67.62	
			$0.9773^{19.8}_{4}$	19.5	−60.6	(1327)
$C_{15}H_{27}BrO_2$	*l*-Menthyl α-bromovalerate	$CHCl_3$	2.5	20	−51.46	(293.5)
		$CHCl_3$	5.0	20	−51.37	
$C_{15}H_{27}N_3O_3$	*l*-Menthyl acetoacetate semicarbazide	$CHCl_3$	*1.5*		−56.1	(1171)
$C_{15}H_{28}O_2$	Propyl-*l*-menthyl acetate	C_6H_6		22	−8.98	(158)
$C_{15}H_{28}O_2$	*l*-Menthyl α-methylbutyrate	C_6H_6	*10.01*	20	−63.97	(1821)
	l-Menthyl β-methylbutyrate	C_6H_6	*10.00*	20	−64.02	
$C_{15}H_{28}O_2$	*l*-Menthyl valerate				−65.55	(1810); *cf.* (294)
		EtOH	*9.04*		−69.5	
$C_{15}H_{28}O_3$	*l*-Menthyl *dl*-α-ethoxypropionate		0.9363	20	−60.3	(1347)
		EtOH	4.66	20	−64.2	
$C_{16}H_{24}O_3S$	*l*-Menthyl benzenesulfonate	$CHCl_3$	2.5	13	−73.20	(908)
		$CHCl_3$	5.0	13	−72.68	
		EtOH	*4.72*	18.8	−73.02	(1578)
		C_6H_6	*5.38*	19.2	−64.17	
		C_6H_6	*5.38*	50.1	−61.53	
		$PhNO_2$	*18.77*	16.0	−65.38	
		$PhNO_2$	*18.77*	78.4	−58.94	
$C_{16}H_{28}O_2$	*l*-Menthyl pentamethylenecarboxylate	EtOH	*9.139*	20	−67.94	(1810)
$C_{16}H_{28}O_2$	*l*-Menthyl $\Delta^{1,2}$-hexenoate	EtOH	*9.032*	20	−68.38	(1810)
	l-Menthyl $\Delta^{2,3}$-hexenoate	EtOH	*9.147*	20	−65.11	
	l-Menthyl $\Delta^{3,4}$-hexenoate	EtOH	*9.711*	20	−60.93	
	l-Menthyl $\Delta^{4,5}$-hexenoate	EtOH	*8.975*	20	−61.25	
$C_{16}H_{28}O_3$	*l*-Menthyl ethylacetoacetate	C_6H_6	*9.94*	20	−60.3	(1811)
			0.9653	20	−63.0	(1327)
		EtOH	4.44	20.3	−67.9	
$C_{16}H_{30}O_2$	*l*-Menthyl hexoate				−62.07	(1810); *cf.* (294)
		EtOH	*9.02*		−64.86	
$C_{16}H_{29}BrO_2$	*l*-Menthyl α-bromohexoate	$CHCl_3$	2.5	20	−48.06	(293.5)
		$CHCl_3$	5.0	20	−48.49	
$C_{17}H_{22}Cl_2O_2$	*l*-Menthyl 2, 3-dichlorobenzoate		1.1607	20	−52.57	(338)
	l-Menthyl 2, 4-dichlorobenzoate		1.1546	20	−63.72	
	l-Menthyl 2, 5-dichlorobenzoate		1.1590	20	−60.62	
	l-Menthyl 2, 6-dichlorobenzoate	$CHCl_3$	*6.36*	20	−34.4	
	l-Menthyl 3, 4-dichlorobenzoate		1.1548	20	−69.16	
	l-Menthyl 3, 5-dichlorobenzoate		1.1535	20	−70.89	
$C_{17}H_{22}BrClO_2$	*l*-Menthyl 2, 3-bromochlorobenzoate		1.2582^{20}_{4}	20	−46.18	(342)
	l-Menthyl 3, 2-bromochlorobenzoate		1.2372^{20}_{4}	20	−51.82	
	l-Menthyl 2, 4-bromochlorobenzoate		1.2683^{20}_{4}	20	−54.57	
	l-Menthyl 4, 2-bromochlorobenzoate		1.2723^{20}_{4}	20	−58.70	
	l-Menthyl 2, 5-bromochlorobenzoate		1.2764^{20}_{4}	20	−50.91	
	l-Menthyl 5, 2-bromochlorobenzoate		1.2677^{20}_{4}	20	−55.68	
	l-Menthyl 3, 4-bromochlorobenzoate		1.2866^{20}_{4}	20	−55.67	
	l-Menthyl 4, 3-bromochlorobenzoate		1.2854^{20}_{4}	20	−59.15	
	l-Menthyl 3, 5-bromochlorobenzoate		1.2444^{20}_{4}	20	−62.90	
$C_{17}H_{22}Br_2O_2$	*l*-Menthyl 2, 3-dibromobenzoate		1.4189^{20}_{4}	20	−41.41	(345)
	l-Menthyl 2, 4-dibromobenzoate		1.4060^{20}_{4}	20	−51.62	
	l-Menthyl 2, 5-dibromobenzoate		1.3821^{20}_{4}	20	−50.95	
	l-Menthyl 2, 6-dibromobenzoate	C_6H_6	15.64	20	−4.68	
	l-Menthyl 3, 4-dibromobenzoate		1.4258^{20}_{4}	20	−55.18	
	l-Menthyl 3, 5-dibromobenzoate		1.4114^{20}_{4}	20	−54.57	
$C_{17}H_{22}N_2O_6$	*l*-Menthyl 2, 4-dinitrobenzoate	C_6H_6	31.1	20	−130.8	(337)
		C_6H_6	7.78	20	−137.2	
	l-Menthyl 2, 6-dinitrobenzoate	C_6H_6	14.1	20	−183.4	
	l-Menthyl 3, 5-dinitrobenzoate	C_6H_6	9.6	20	−70.1	
$C_{17}H_{23}IO_2$	*l*-Menthyl *o*-iodobenzoate		1.375^{20}_{20}	20	−63.72	(342)
	l-Menthyl *m*-iodobenzoate		1.360^{20}_{20}	20	−60.75	
	l-Menthyl *p*-iodobenzoate		1.311^{20}_{20}	20	−62.48	

Esters of menthol, allomenthol and carvomenthol.—(Continued)

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_{17}H_{24}O_2$	*l*-Menthyl benzoate	$CHCl_3$	2.5	13	−86.04	(908); *cf.* (50, 103, 105, 339)
		$CHCl_3$	5.0	13	−85.60	
		$CHCl_3$	5		−84.39	(1630)
		C_6H_6	1		−90.59	
$C_{17}H_{24}O_2$	Carvomenthyl benzoate (λ = 5780)		1.006	20	−12.9	
$C_{17}H_{25}NO_2$	*l*-Neomenthyl phenylcarbamate ($C_{10}H_{19}O.CO.NH.C_6H_5$)	$CHCl_3$	*5*	?	−26.77	(1630)
$C_{17}H_{26}O_3S$	*l*-Menthyl *p*-toluenesulfonate	$CHCl_3$	2.5	13	−66.80	(908.5)
		$CHCl_3$	5.0	13	−66.76	
$C_{17}H_{28}O_2$	*l*-Menthyl Δ^1-tetrahydrobenzoate	EtOH	*9.098*	20	−74.64	(1810)
	l-Menthyl Δ^2-tetrahydrobenzoate	EtOH	*9.103*	20	−59.44	
$C_{17}H_{28}O_3$	*l*-Menthyl propylideneacetoacetate	C_6H_6	1.59		−34.9	(825)
$C_{17}H_{28}O_3$	*l*-Menthyl allylacetoacetate	C_6H_6	*10.03*	20	−58.3	(1811)
$C_{17}H_{30}O_2$	*l*-Menthyl $\Delta^{1,2}$-heptenoate	EtOH	*9.006*	20	−66.03	(1810)
$C_{17}H_{30}O_2$	*l*-Menthyl cyclohexanecarboxylate	EtOH	*9.204*	20	−59.11	(1810)
$C_{17}H_{30}O_3$	*l*-Menthyl *n*-propylacetoacetate	C_6H_6	*10.03*	20	−57.3	(1811)
$C_{17}H_{32}O_2$	*l*-Menthyl heptoate				−58.85	(1810); *cf.* (294)
		EtOH	*9.12*		−61.94	
$C_{18}H_{24}O_3$	*l*-Menthyl benzoylformate	EtOH	4.78	20	−44.4	(1326)
$C_{18}H_{24}O_4$	*l*-Menthyl hydrogen phthalate	$CHCl_3$	5.03		−90.67	(1630)
	d-Neomenthyl hydrogen phthalate	$CHCl_3$	2.5		68.71	
$C_{18}H_{25}ClO_2$	*l*-Menthyl *l*-phenylchloroacetate	EtOH	3.99	15	−149.8	(1346)
	l-Menthyl *d*-phenylchloroacetate	EtOH	4.37	14.5	5.7	
	l-Menthyl *d*-phenylchloroacetate (λ = 5461)	EtOH	4.37	14.5	80	
	l-Menthyl *dl*-phenylchloroacetate	EtOH	3.92	16	−72.2	
	l-Menthyl *dl*-phenylchloroacetate (λ = 5461)	EtOH	3.92	16	−85.9	
$C_{18}H_{24}Br_2N_2O_2$	*l*-Menthyl bromomethylene-*p*-bromophenylhydrazonecarboxylate	C_6H_6	1.60		−73.45	(1168)
$C_{18}H_{24}BrClN_2O_2$	*l*-Menthyl bromomethylene-*p*-chlorophenylhydrazonecarboxylate	C_6H_6	1.60		67.61	(1168)
$C_{18}H_{25}BrN_2O_2$	*l*-Menthyl bromomethylenephenylhydrazonecarboxylate ($C_6H_5.NH.N\colon CBr.CO.OC_{10}H_{19}$)	C_6H_6	1.62		82.45	(1168)
$C_{18}H_{26}O_2$	*l*-Menthyl phenylacetate		1.002	20	−68.70	(339)
			0.9400	100	−65.56	
$C_{18}H_{26}O_2$	*l*-Menthyl *o*-toluate		0.9982	20	−84.35	(339)
			0.9383	100	−81.41	
	l-Menthyl *m*-toluate		0.9946	20	−87.59	
			0.9352	100	−85.63	
	l-Menthyl *p*-toluate		0.9937	20	−89.93	
			0.9336	100	−86.56	
		$CHCl_3$	2.5	13	−95.36	
		$CHCl_3$	5.0	13	−95.22	
$C_{18}H_{26}O_3$	*l*-Menthyl *o*-methoxybenzoate		1.045	20	−51.08	(339)
			0.9823	100	−53.37	
	l-Menthyl *m*-methoxybenzoate		1.034	20	−85.39	
			0.9766	100	−83.69	
	l-Menthyl *p*-methoxybenzoate		1.036	20	−86.47	
			0.9766	100	−82.30	
$C_{18}H_{26}O_3$	*l*-Menthyl *d*-mandelate	EtOH	3.60	20	−7.6	(1326)
	l-Menthyl *l*-mandelate	EtOH	4.37	20	−138.6	
$C_{18}H_{30}O_2$	*l*-Menthyl 2, 4-dimethylsorbate	EtOH	*9.77*	20	−59.80	(1821)
$C_{18}H_{32}O_3$	*l*-Menthyl diethylacetoacetate		0.9605	20	−54.8	(1327)
$C_{18}H_{34}O_2$	*l*-Menthyl 2, 4-dimethylhexoate	C_6H_6	*9.84*	20	−57.38	(1821)
$C_{18}H_{34}O_2$	*l*-Menthyl octoate		0.8977	20	−55.25	(294)
$C_{19}H_{24}O_2$	*l*-Menthyl phenylpropiolate	$CHCl_3$	10	21	−58.65	(900)
		$CHCl_3$	2.5	21	−60.20	
		Me_2CO	10	21	−55.55	
		Me_2CO	2.5	20	−52.40	
		C_6H_6	*9.84*	20	−71.77	(1821)

Esters of menthol, allomenthol and carvomenthol.—(*Continued*)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{19}H_{24}BrN_3O_2$	*l*-Menthyl *p*-bromophenylazocyanoacetate	C_6H_6	1.38		−42.75	(227)
$C_{19}H_{25}NO_6$	2-Methyl 1-*l*-menthyl 3-nitrophthalate*	C_6H_6	3.2224		−122.9	(344)
	1-Methyl 2-*l*-menthyl 3-nitrophthalate*	C_6H_6	2.9340		−102.3	
	Methyl *l*-menthyl 4-nitrophthalate	C_6H_6	2.2304		−61.6	
$C_{19}H_{25}NO_6$	Methyl *l*-menthyl 2-nitroterephthalate		1.093	100	−92.41	(341.5)
		C_6H_6	1.73	18	−141.5	
	Methyl *l*-menthyl 3-nitroterephthalate		1.133	20	68.31	
			1.096	100	62.19	
$C_{19}H_{26}O_2$	*l*-Menthyl cinnamate	$CHCl_3$	10	20	−60.00	(900)
		Me_2CO	10	20	−64.45	
		Me_2CO	2.5	20	−63.60	
$C_{19}H_{26}O_2$	*l*-Menthyl atropate (α-phenylacrylate)	C_6H_6	*10*	20	−63.03	(1821)
			1.000_4^{100}	100	76.91	
$C_{19}H_{26}O_4$	Methyl *l*-menthyl terephthalate		1.054_4^{20}	20	77.49	
$C_{19}H_{27}BrN_2O_2$	*l*-Menthyl bromomethylene-*p*-tolylphenylhydrazonecarboxylate	C_6H_6	1.62		86.95	(1168)
$C_{19}H_{28}O_2$	*l*-Menthyl α-phenylpropionate	C_6H_6	*10.00*	20	−61.87	(1821)
	l-Menthyl β-phenylpropionate	C_6H_6	*9.93*	20	−58.48	(1821)
		$CHCl_3$	10	20	−59.55	(900)
		$CHCl_3$	2.5	20	−60.80	
		Me_2CO	10	20	−56.45	
		Me_2CO	2.5	20	−60.00	
$C_{19}H_{28}O_3$	*l*-Menthyl *o*-ethoxybenzoate		0.9641	100	−51.75	(344)
	l-Menthyl *m*-ethoxybenzoate		1.017	20	−80.26	
			0.9582	100	−78.10	
	l-Menthyl *p*-ethoxybenzoate		0.9622	100	−78.39	
$C_{19}H_{28}O_3$	*l*-Menthyl *d*-α-hydroxy-β-phenylpropionate	C_6H_6	1.40	17	−27.1	(1357)
		$CHCl_3$	2.69	15.5	−36.9	
		Me_2CO	0.87		−49.4	
$C_{19}H_{29}NO_2$	*l*-Menthyl *o*-dimethylaminobenzoate			100	−33.29	(344)
	l-Menthyl *p*-dimethylaminobenzoate			100	−85.13	
$C_{20}H_{26}O_3S$	*l*-Menthyl naphthalene-β-sulfonate	$CHCl_3$	2.5	13	−57.12	(908.5)
		$CHCl_3$	5.0	13	−56.50	
		EtOH	*1.80*	14.7	−56.86	(1578)
		C_6H_6	*1.02*	18.3	−50.52	
		$PhNO_2$	*8.64*	12.7	−41.20	
$C_{20}H_{27}N_3O_2$	*l*-Menthyl *p*-tolylazocyanoacetate	C_6H_6	3.01		−53.7	(227)
$C_{20}H_{27}ClN_2O_3$	*l*-Menthyl *p*-chlorophenylazoacetoacetate	C_6H_6	1.6		−55.79†	(1168)
$C_{20}H_{27}BrN_2O_3$	*l*-Menthyl *p*-bromophenylazoacetoacetate	C_6H_6	1.60		−46.88†	(1168)
$C_{20}H_{27}NO_6$	Ethyl *l*-menthyl 2-nitroterephthalate		1.410	20	−91.58	(341.5)
			1.08	100	−85.45	
		C_6H_6	2.04	18	−130.5	
	Ethyl *l*-menthyl 3-nitroterephthalate		1.128	20	65.43	
			1.074	100	60.36	
$C_{20}H_{27}NO_6$	2-Ethyl 1-*l*-menthyl 3-nitrophthalate*	C_6H_6	2.3920		−125.4	(344)
	1-Ethyl 2-*l*-menthyl 3-nitrophthalate*	C_6H_6	2.7906		−93.45	
$C_{20}H_{28}N_2O_3$	*l*-Menthyl phenylazoacetoacetate (initial)	C_6H_6	1.62		−52.5†	(1168)
$C_{20}H_{28}O_2$	*l*-Menthyl α-methylcinnamate	C_6H_6	*9.95*	20	−62.60	(344)
	l-Menthyl β-methylcinnamate	C_6H_6	*9.99*	20	−65.89	
	l-Menthyl methylatropate (α-phenylcrotonate)	C_6H_6	*10.00*	20	−46.13	
$C_{20}H_{28}O_3$	*l*-Menthyl α-benzoylpropionate	EtOH	*10.03*	20	−57.7	(1811)
$C_{20}H_{28}O_3$	*l*-Menthyl *o*-allyloxybenzoate		0.9689	100	−55.35	(339)
	l-Menthyl *p*-allyloxybenzoate		1.027	20	−79.69	
			0.9689	100	−74.95	
$C_{20}H_{28}O_4$	Ethyl *l*-menthyl terephthalate		1.055	20	76.91	(341.5)
			0.995	100	72.43	
$C_{20}H_{29}NO_3$	*l*-Menthyl β-phenylpropionylcarbamate	EtOH	1.00		−65.0	(610)
$C_{20}H_{29}N_3O_4$	*l*-Menthyl acetoacetate *p*-nitrophenylhydrazide ($NO_2.C_6H_4.N_2H_2.C(CH_3){:}CH.CO.C_{10}H_{19}$)	C_6H_6	1.41		−42.5	(1171)
$C_{20}H_{30}O_2$	*l*-Menthyl β-phenyl-α-methylpropionate	C_6H_6	*10.04*	20	−50.73	(1821)
$C_{20}H_{30}O_2$	*l*-Menthyl α-phenylbutyrate	C_6H_6	*10.00*	20	−26.78	

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* The numbers, 1 and 2, refer to the carboxyl groups which carry the menthyl and alkyl radicals. † Mutarotation.

Esters of menthol, allomenthol and carvomenthol.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{21}H_{30}N_2O_3$	*l*-Menthyl *p*-tolylazoacetoacetate	C_6H_6	1.63		−61.6*	(1168)
$C_{20}H_{30}O_2$	*l*-Menthyl γ-phenylbutyrate	C_6H_6?	*10.02*	20	−57.0	(1811)
$C_{20}H_{30}O_2$	*l*-Menthyl *l*-β-phenylbutyrate	C_6H_6	*9.86*	20	−76.26	(1821)
$C_{20}H_{30}O_3$	*l*-Menthyl *o*-propoxybenzoate		1.019	20	−53.5	(339)
			0.9589	100	−56.63	
	l-Menthyl *m*-propoxybenzoate		1.010	20	−75.65	
			0.9511	100	−73.93	
	l-Menthyl *p*-propoxybenzoate		1.016	20	−78.66	
			0.9569	100	−73.60	
$C_{20}H_{30}O_3$	*l*-Menthyl *o*-isopropoxybenzoate		1.034	20	−53.08	
			0.9766	100	−56.54	
	l-Menthyl *p*-isopropoxybenzoate		1.011	20	−77.42	
			0.9514	100	−73.37	
$C_{20}H_{30}O_3$	*l*-Menthyl *dl*-phenylethoxyacetate		1.0007	20	−65.65	(1347)
		EtOH	4.320	20	−68.4	
$C_{20}H_{34}O_4$	Allo-*l*-menthyl hydrogen camphorate	C_6H_6	1.022	20	−26.45	(344)
$C_{21}H_{26}O_2$	*l*-Menthyl α-naphthoate	EtOH	*9.09*	20	−79.08	(1810)
	l-Menthyl β-naphthoate	C_6H_6	*9.97*	20	−91.3	(181.05)
		$CHCl_3$	*2.5*	13	−91.12	
		$CHCl_3$	*5.0*	13	−90.60	
$C_{21}H_{28}O_2$	*l*-Menthyl Δ^1-dihydro-α-naphthoate	EtOH	*9.13*	20	−69.12	(1810)
	l-Menthyl Δ^2-dihydro-α-naphthoate	AcOEt	*9.92*	20	92.85	
		EtOH	*4.12*	20	89.60	
	l-Menthyl Δ^2-dihydro-β-naphthoate	EtOH	*9.98*	20	−41.40	(1810.5)
	l-Menthyl Δ^3-dihydro-β-naphthoate	EtOH	*9.96*	20	−53.14	
$C_{21}H_{28}O_2$	*l*-Menthyl cinnamenylacrylate	C_6H_6	*9.98*	20	−75.14	(1821)
$C_{21}H_{28}O_3$	*l*-Menthyl benzylideneacetoacetate	C_6H_6	*9.96*	20	−11.2	(1811)
$C_{21}H_{29}NO_6$	Propyl *l*-menthyl 2-nitroterephthalate		1.118	20	−91.12	(341.5)
			1.059	100	−87.12	
		C_6H_6	2.41	18	−129.7	
	Propyl *l*-menthyl 3-nitroterephthalate		1.130	20	62.25	(341.5)
			1.060	100	58.73	
$C_{21}H_{29}NO_6$	2-Propyl *l*-1-menthyl 3-nitrophthalate*	C_6H_6	2.2228		−116.9	(344)
	1-Propyl *l*-2-menthyl 3-nitrophthalate*	C_6H_6	2.5184		−83.4	
$C_{21}H_{30}O_2$	*l*-Menthyl tetrahydro-α-naphthoate	EtOH	*9.11*	20	−47.57	(1810.5)
		EtOH	*9.106*	20	−47.57	(1810)
	l-Menthyl tetrahydro-β-naphthoate	EtOH	*9.89*	20	−53.04	
		$CHCl_3$	9.86	20	−53.04	(1810.5)
$C_{21}H_{30}O_2$	*l*-Menthyl 4-phenyl-$\Delta^{2,3}$-pentenoate	C_6H_6	*10.03*	20	−47.54	(1821)
$C_{21}H_{30}O_3$	*l*-Menthyl α-benzoylbutyrate	EtOH	*9.92*	20	−55.9	(1811)
		C_6H_6	*9.98*	20	−54.3	
$C_{21}H_{30}O_4$	*l*-Menthyl propyl phthalate		1.0447	20	64.49	(344)
$C_{21}H_{30}O_4$	*l*-Menthyl propyl terephthalate		1.041	20	73.79	(341.5)
			0.9845	100	69.69	
$C_{21}H_{31}NO_2$	*l*-Menthyl β-benzylaminocrotonate	C_6H_6	1.61		−59.8	
$C_{21}H_{32}O_2$	*l*-Menthyl δ-phenylvalerate	C_6H_6	*10.03*	20	−33.86	(1821)
$C_{21}H_{36}O_4$	Orthomethyl allomenthyl camphorate		1.020	20	−20.1	(344)
			0.9656	100	−21.1	
	Allomethyl orthomenthyl camphorate		1.021	20	−25	
			0.9629	100	−26.3	
$C_{21}H_{38}O_3$	Di-*l*-menthyl carbonate	C_6H_6	*2.021*	21	−92.52	(50)
$C_{21}H_{39}NO_2$	*l*-Menthyl *l*-menthylcarbamate ($C_{10}H_{19}O.CO.NH.C_{10}H_{19}$)	EtOH	2.55	?	−91.03	(1630)
$C_{22}H_{28}O_3$	*l*-Menthyl α-methoxynaphthoate		1.076	20	−78.27	(339)
			1.022	100	−70.32	
	l-Menthyl β-methoxynaphthoate		1.083	20	−48.94	
			1.025	100	−46.84	
$C_{22}H_{28}O_4$	*l*-Menthyl piperate	$CHCl_3$	2.5	15.3	−52.76	(905)
		$CHCl_3$	5.0	15.3	−53.02	
$C_{22}H_{30}O_3$	*l*-Menthyl α-benzoyl-Δ^3-pentenoate	C_6H_6	*9.99*	20	−51.4	(1811)
$C_{22}H_{30}O_4$	*l*-Menthyl β, γ-hydropiperate	$CHCl_3$	2.5	15.3	−46.08	(905)
		$CHCl_3$	5.0	15.3	−45.92	
	l-Menthyl α, β-hydropiperate	$CHCl_3$	2.5	15.3	−42.12	
		$CHCl_3$	5.0	15.3	−42.22	

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* The numbers, 1 and 2, refer to the carboxyl groups which carry the menthyl and alkyl radicals.

Esters of menthol, allomenthol and carvomenthol.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{22}H_{30}O_5$	*l*-Menthyl piperonylbutyrate	$CHCl_3$	2.5	15.3	−38.00	(905)
		$CHCl_3$	5.0	15.3	−39.68	
$C_{22}H_{31}NO_6$	2-Isobutyl 1-*l*-menthyl 3-nitrophthalate*	C_6H_6	2.1396		−115	(344)
	1-Isobutyl 2-*l*-menthyl 3-nitrophthalate*	C_6H_6	2.3868		−79.2	
$C_{22}H_{31}NO_6$	*n*-Butyl *l*-menthyl 2-nitroterephthalate		1.098	20	−90.49	(341.5)
			1.041	100	−84.53	
		C_6H_6	2.02	18	−124.7	
	n-Butyl *l*-menthyl 3-nitroterephthalate		1.136	20	60.23	
			1.057	100	57.53	
$C_{22}H_{32}O_3$	*l*-Menthyl α-benzoylvalerate	EtOH	*10.00*	20	−52.3	(1811)
$C_{22}H_{32}O_3$	*l*-Menthyl β-phenylethylacetoacetate	C_6H_6	*9.97*	20	−51.6	(1811)
		EtOH	*10.05*	20	−53.8	
$C_{22}H_{32}O_4$	*l*-Menthyl isobutyl phthalate		1.0338	20	−63.96	(344)
$C_{22}H_{32}O_4$	*n*-Butyl *l*-menthyl terephthalate		1.037	20	71.48	(341.5)
			0.9848	100	66.91	
	Isobutyl *l*-menthyl terephthalate		1.044	20	73.91	
			0.988	100	69.92	
$C_{22}H_{34}O_3$	*l*-Menthyl *o*-isoamyloxybenzoate		1.003	20	−54.01	(339)
			0.9442	100	−56.69	
	l-Menthyl *m*-isoamyloxybenzoate		0.9947	20	−69.53	
			0.9363	100	−68.66	
	l-Menthyl *p*-isoamyloxybenzoate		0.9954	20	−71.57	
			0.9400	100	−67.57	
$C_{22}H_{40}O_3$	*l*-Menthyl *sec.*-octylacetoacetate	C_6H_6	*10.00*	20	−47.8	(1811)
$C_{23}H_{32}O_3$	*l*-Menthyl cinnamylacetoacetate	C_6H_6	*9.98*	20	−41.3	(1811)
$C_{23}H_{34}O_3$	*l*-Menthyl γ-phenylpropylacetoacetate	C_6H_6	*10.00*	20	−45.4	(1811)
		EtOH	*9.98*	20	−49.0	
$C_{23}H_{34}O_4$	*l*-Menthyl isoamyl phthalate		1.0215	20	55.9	(344)
$C_{23}H_{40}O_4$	Di-*l*-menthyl malonate	$CHCl_3$	2.5	15	−79.54	(906)
		$CHCl_3$	5.0	15	−79.24	
$C_{24}H_{34}O_4$	Cyclohexyl *l*-menthyl terephthalate		1.036	20	67.69	(341.5)
			1.006	100	62.03	
$C_{24}H_{30}O_2$	*l*-Menthyl diphenylacetate	C_6H_6	*10.0*	20	−66.70	(1821)
$C_{24}H_{30}O_3$	*l*-Menthyl *o*-benzyloxybenzoate		1.142	20	−47.07	(339)
			1.083	100	−44.49	
	l-Menthyl *p*-benzyloxybenzoate		1.064	20	−69.68	
			1.0015	100	−65.29	
$C_{24}H_{36}O_4$	Hexyl *l*-menthyl phthalate		1.0179	20	−60.26	(344)
$C_{24}H_{38}O_4$	Di-*l*-menthyl acetylenedicarboxylate	$CHCl_3$	2.5		−84.2	(908)
		Me_2CO	2.5		−85.6	
$C_{24}H_{40}O_4$	Di-*l*-menthyl fumarate	$CHCl_3$	2.5		−100.6	(908)
		Me_2CO	2.5		−99.4	
$C_{24}H_{42}O_4$	Di-*l*-menthyl succinate	$CHCl_3$	2.5	15	−82.40	(906); *cf.* (50)
		$CHCl_3$	5.0	15	−81.90	
		Me_2CO	2.5		−81.4	
$C_{24}H_{42}O_6$	Di-*l*-menthyl *l*-tartrate		1.0450	16.3	−76.11	(1579.5)
			0.9547	134.9	−84.22	
		EtOH	*2.42*	20	−76.06	
		EtOH	*7.054*	20	−75.60	
		C_6H_6	*5.394*	20	−74.94	
		$PhNO_2$	*5.348*	20	−89.32	
$C_{24}H_{46}O_2$	*l*-Menthyl myristate	$CHCl_3$	2.5	20	−42.74	(910)
		$CHCl_3$	5.0	20	−42.83	
		EtOH	2.5	20	−43.86	
		EtOH	5.0	20	−43.41	
$C_{24}H_{45}BrO_2$	*l*-Menthyl α-bromomyristate	$CHCl_3$	2.5	20	−36.44	(293.5)
$C_{25}H_{29}NO_6$	*l*-Menthyl α-benzyl 3-nitrophthalate	C_6H_6	2.59	18.5	−83.0	(344)
$C_{25}H_{30}O_2$	*l*-Menthyl α-phenylcinnamate	C_6H_6	*9.76*	20	−53.44	(1821)
	l-Menthyl β-phenylcinnamate	C_6H_6	*9.92*	20	−37.92	
$C_{25}H_{32}O_2$	*l*-Menthyl α, β-diphenylpropionate	C_6H_6	*9.96*	20	−86.04	(1821)
	l-Menthyl β, β-diphenylpropionate	C_6H_6	*9.94*	20	−61.72	

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* The numbers, 1 and 2, refer to the carboxyl groups which carry the menthyl and alkyl radicals.

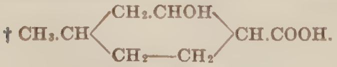
Esters of menthol, allomenthol and carvomenthol.—(Continued)

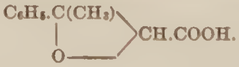
Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{25}H_{42}O_4$	*l*-Menthyl mesaconate		0.9904	17.6	−91.05	(343)
$C_{25}H_{44}O_4$	Di-*l*-menthyl glutarate	$CHCl_3$	2.5	15	−80.16	(906)
		$CHCl_3$	5.0	15	−80.26	
$C_{25}H_{44}O_4$	*l*-Menthyl pyrotartrate		0.978	11.8	−71.6	(343)
$C_{26}H_{30}O_3$	*l*-Menthyl α-benzoylcinnamate	C_6H_6	*9.75*	20	−77.4	(1811)
$C_{26}H_{30}O_4$	*l*-Menthyl dibenzoylacetate	C_6H_6	*10*	20	−64.07	(1833)
$C_{26}H_{32}O_2$	*l*-Menthyl α-benzylcinnamate	C_6H_6	*9.64*	20	−144.9	(1811)
$C_{26}H_{32}O_3$	*l*-Menthyl α-benzoyl-β-phenylpropionate	C_6H_6	*10.03*	20	−60.8	(1811)
$C_{26}H_{34}O_2$	*l*-Menthyl dibenzylacetate	C_6H_6	*9.64*	20	−24.4	(1811)
$C_{26}H_{40}O_4$	*l*-Menthyl octyl phthalate		1.0095	20	61.4	(344)
$C_{26}H_{40}O_4$	Octyl *l*-menthyl terephthalate		0.999	20	59.25	
			0.946	100	55.99	
$C_{26}H_{42}O_4$	Di-*l*-menthyl muconate	$CHCl_3$	2.5	15.3	−93.40	(905)
$C_{26}H_{44}O_4$	Di-*l*-menthyl β, γ-hydromuconate	$CHCl_3$	2.5	15.3	−88.78	(905)
		$CHCl_3$	5.0	15.3	−88.80	
	Di-*l*-menthyl α, β-hydromuconate	$CHCl_3$	2.5	15.3	−80.78	
		$CHCl_3$	5.0	15.3	−81.52	
$C_{26}H_{46}O_4$	Di-*l*-menthyl adipate	$CHCl_3$	2.5	15.3	−83.60	(905); *cf.* (906)
		$CHCl_3$	5.0	15.3	−83.80	
$C_{26}H_{49}BrO_2$	*l*-Menthyl α-bromopalmitate	$CHCl_3$	2.5	20	−33.98	(910)
		$CHCl_3$	5.0	20	−34.34	
$C_{26}H_{50}O_2$	*l*-Menthyl palmitate	$CHCl_3$	2.5	20	−39.34	(293.5)
		$CHCl_3$	5.0	20	−39.79	
		EtOH	2.5	20	−40.54	
		EtOH	5.0	20	−40.17	
$C_{27}H_{34}O_3$	*l*-Menthyl α-benzoyl-γ-phenylbutyrate	C_6H_6	*9.95*	20	−56.7	(1811)
$C_{27}H_{48}O_4$	Di-*l*-menthyl pimelate	$CHCl_3$	2.5	15	−77.82	(906)
		$CHCl_3$	5.0	15	−78.31	
$C_{28}H_{32}O_3$	*l*-Menthyl β-benzyloxynaphthoate			20	−87.27	(339)
				100	−77.82	
$C_{28}H_{34}O_3$	*l*-Menthyl *l*-α-benzoyl-δ-phenyl-Δ^3-pentenoate	C_6H_6	*9.97*	20	−86.7	(1811)
	l-Menthyl *d*-α-benzoyl-δ-phenyl-Δ^3-pentenoate	C_6H_6	*9.95*	20	−25.9	(1811)
$C_{28}H_{36}O_3$	*l*-Menthyl α-benzoyl-δ-phenylvalerate	C_6H_6	*9.98*	20	−44.0	(1811)
$C_{28}H_{42}O_4$	Di-*l*-menthyl phthalate	C_6H_6	*2.006*	20	−94.72	(50)
$C_{28}H_{42}O_4$	Di-*l*-menthyl terephthalate	$CHCl_3$	*9.96*	20	−102.64	(1810.5)
$C_{28}H_{44}O_4$	Di-*l*-menthyl $\Delta^{1,4}$-dihydroterephthalate	$CHCl_3$	10	20	−104.55	(1810.5)
$C_{28}H_{46}O_4$	Di-*l*-menthyl Δ^1-tetrahydroterephthalate	$CHCl_3$	10	20	−69.42	(1810.5)
	Di-*l*-menthyl Δ^2-tetrahydroterephthalate	$CHCl_3$	10.03	20	−76.09	
$C_{28}H_{46}O_8$	Di-*l*-menthyl diacetyl-*l*-tartrate		1.0550	16	−70.28	(1579.5)
			0.9477	150	−77.54	
		EtOH	*5.801*	20	−71.77	
		C_6H_6	*5.219*	20	−61.37	
		$PhNO_2$	*5.357*	20	−69.54	
$C_{28}H_{46}O_8$	*l*-Menthyl diacetyl-*dl*-tartrate		0.9540	145.6	−55.52	(1580)
			0.9683	130	−55.29	
		EtOH	*0.455*	20	−57.3	
		C_6H_6	*5.20*	17.2	−48.12	
		C_6H_6	*5.20*	37.7	−50.79	
		C_6H_6	*5.20*	20	−48.59	
		$PhNO_2$	*4.38*	17.2	−47.73	
		$PhNO_2$	*4.38*	37.4	−49.88	
	l-Menthyl diacetyl-*d*-tartrate		0.9970	97.2	−44.63	
			0.9668	134.4	−41.96	
$C_{28}H_{48}O_4$	Di-*l*-menthyl *trans*-hexahydroterephthalate	$CHCl_3$	*10.16*	20	−74.72	(1810.5)
$C_{28}H_{50}O_4$	Di-*l*-menthyl suberate	$CHCl_3$	2.5	15	−73.28	(906)
		$CHCl_3$	5.0	15	−73.56	
$C_{28}H_{54}O_2$	*l*-Menthyl stearate	$CHCl_3$	2.5	20	−36.94	(910)
		$CHCl_3$	5.0	20	−36.71	
		EtOH	2.5	20	−37.70	
		EtOH	5.0	20	−37.73	

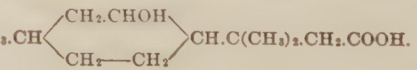
Esters of menthol, allomenthol and carvomenthol.—(Continued)

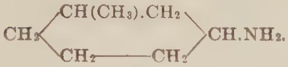
Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{29}H_{52}O_4$	Di-*l*-menthyl azelate	$CHCl_3$	2.5	15	−72.32	(906)
		$CHCl_3$	5.0	15	−72.68	
$C_{30}H_{50}O_6$	Di-*l*-menthyl ethylidene-*bis*-acetoacetate	C_6H_6	1.60		−26.5*	(825)
$C_{30}H_{54}O_4$	Di-*l*-menthyl sebacate	$CHCl_3$	2.5	15	−66.72	(906)
		$CHCl_3$	5.0	15	−67.08	
$C_{31}H_{52}O_6$	Di-*l*-menthyl propylidene-*bis*-acetoacetate	C_6H_6	0.521		−26.9	(825)
$C_{32}H_{54}O_6$	Di-*l*-menthyl *n*-butylidene-*bis*-acetoacetate	C_6H_6	0.742		−16.8	(825)
	Di-*l*-menthyl isobutylidene-*bis*-acetoacetate	C_6H_6	1.17		−46.0*	
$C_{35}H_{52}O_6$	Di-*l*-menthyl benzylidene-*bis*-acetoacetate	C_6H_6	0.575		−30.4	(825)
$C_{36}H_{63}NO_6$	*l*-Trimenthyl nitrilotriacetate ($N(CH_2.CO.OC_{10}H_{19})_3$)		1.0027	19	−39.47	(653)
			0.9917	36.2	−38.78	
			0.9773	58.4	−38.03	
			0.9637	79.4	−37.39	
			0.9515	98.0	−36.81	
		MeOH	0.9183	20	−88.22	
		MeOH	1.443	20	−88.03	
		MeOH	2.190	20	−87.89	
	Homologues of menthol and their esters					
$C_{11}H_{22}O$	Methylmenthol	C_6H_6		21	−2.43	(158)
$C_{12}H_{24}O$	Ethylmenthol	C_6H_6		22	4.91	(158)
$C_{13}H_{24}O_2$	Methylmenthyl acetate	C_6H_6		22	−18.11	(158)
$C_{13}H_{26}O$	*n*-Propylmenthol	C_6H_6		22	29.7	(158)
$C_{14}H_{26}O_2$	Ethylmenthyl acetate	C_6H_6		21	−6.6	(158)
$C_{15}H_{28}O_2$	Propylmenthyl acetate	C_6H_6		22	−8.98	(158)
$C_{15}H_{30}O$	Isoamylmenthol	C_6H_6		22	33.73	(158)
$C_{17}H_{26}O$	Benzylmenthol	C_6H_6		20	−43.19	(158)
$C_{19}H_{26}O_4$	Methylmenthyl phthalate			20	83.62	(344)
	POLYHYDRIC ALCOHOLS					
$C_{15}H_{16}O_2$	*l*-α, β-Dihydroxy-α, β-diphenylpropane	Me_2CO	1.648	12.5	34.0	(1355)
$C_{16}H_{18}O_2$	*l*-α, β-Dihydroxy-α, β-diphenylbutane ($C_2H_5.C(C_6H_5)OH.CH(C_6H_5)OH$)	EtOH	2.883	12.5	19.6	(1355)
		$CHCl_3$	2.044	10.5	3.2	
		Me_2CO	4.674	11.7	27.4	
	KETONES					
$C_7H_{12}O_2$	1-Methylcyclohexanol-3-one		1.0399_4^{19}		21.6	(2237)
$C_7H_{11}BrO$	Bromo-1, 3-methylcyclohexanone	PhMe			−47.9	(2237)
	CARBOXYLIC ACIDS					
	HYDROXY ACIDS (INCLUDING THOSE DERIVED FROM MENTHOL AND THEIR ESTERS)					
$C_8H_{14}O_3$	*d*-1-Methylcyclohexan-3-ol-4-carboxylic acid†	EtOH	0.409	17	−31.8	(709)
$C_{10}H_{10}O_3$	*d*-β-Phenyl-β-methylglycidic acid‡	H_2O	3.0		16.6	(2212)
$C_{10}H_{18}O_3$	Ethyl *d*-1-methylcyclohexan-3-ol-4-carboxylate	AcOEt	5.11		5.9	(288)
$C_{11}H_{20}O_3$	*d*-Isomentholcarboxylic acid	EtOH	0.4990		12.0	(709)
$C_{12}H_{20}O_2$	Pulegolacetic anhydride§ (isomeride a)	EtOH	3.17	20	18.21	(2078)
	(isomeride b)	EtOH	2.86	20	21.65	(2078)
$C_{12}H_{22}O_3$	Menthoxyacetic acid ($C_{10}H_{19}O.CH_2.COOH$)	MeOH	4.22	20	−92.93	(652)
$C_{15}H_{26}O_3$	Allyl menthoxyacetate		0.9720	14	−93.15	(652)
			0.9640	25	91.51	
$C_{15}H_{27}NO_2$	Menthoxyacetic allylamide		0.9667	20	−76.11	(652)
$C_{15}H_{27}NO_2$	Menthyl allylaminoacetate		0.9488	20.5	−63.43	(652)
$C_{15}H_{28}O_3$	Propyl menthoxyacetate		0.9547	20	91.46	(652)
$C_{15}H_{29}NO_2$	Menthoxyacetic propylamide		0.9545	20	−75.97	(652)
$C_{15}H_{29}NO_2$	Menthyl propylaminoacetate		0.9330	20.0	−62.08	(652)
	AMINES					
	MONOAMINES					
	Monoamines excluding menthylamine					
$C_7H_{15}N$	1, 3-Methylcyclohexylamine‖		0.8456	20	−1.9	(767)

* Mutarotation.

† 
$CH_3.CH<(CH_2.CHOH)(CH_2—CH_2)>CH.COOH.$

‡ 
$C_6H_5.C(CH_3)(O)>CH.COOH.$

§ Lactone of 
$CH_3.CH<(CH_2.CHOH)(CH_2—CH_2)>CH.C(CH_3)_2.CH_2.COOH.$

‖ 
$CH_2<(CH(CH_3).CH_2)(CH_2—CH_2)>CH.NH_2.$

Monoamines excluding menthylamine.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_9H_{17}N$	*d*-Decahydroquinoline*	EtOH			4.81	(1398)
	l-Decahydroquinoline*	EtOH			−4.5	
$C_{10}H_{14}ClN$	*l*-Methylhydrindamine hydrochloride†	H_2O	1.81		−30.3	(2007)
$C_{10}H_{17}N$	Carvylamine‡		0.9168^{19}_{19}	19	105.8	(831)
$C_{14}H_{26}N_2O$	Nitroso-α-di-(3-methylcyclohexyl)amine§	Et_2O	11.11	20	−34	(2116)
$C_{21}H_{31}NO$	Benzoyl-α-dimethylcyclohexylamine‖	Et_2O	6.90		−34.65	(2116)
	Benzoyl-β-dimethylcyclohexylamine‖	EtOH	7.85		−11.88	
$C_{26}H_{31}BrNO_4S$	Benzylhydrindamine bromocamphorsulfonate (α)	EtOH	1.00		50	(1076)
		$CHCl_3$	0.80		41.6	
	Benzylhydrindamine bromocamphorsulfonate (β)	EtOH	1.00		51.5	
		$CHCl_3$	1.60		42.8	

Menthylamine, its salts and acyl derivatives

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{21}N$	*l*-Menthylamine		0.860	7	−38.07	(145, 2126)
		EtOH	11.27		−31.90	(145)
$C_{10}H_{22}BrN$	*d*-Menthylamine hydrobromide	H_2O	*1.30*	14	13.83	(145)
		Et_2O	*1.36*	12.5	5.26	
$C_{10}H_{22}ClN$	*l*-Menthylamine hydrochloride	H_2O	0.8	15	−36.4	(1663)
	d-Menthylamine hydrochloride	H_2O	*2.77*	15	17.24	(145)
		Et_2O	*1.71*	9	8.34	
$C_{10}H_{22}IN$	*d*-Menthylamine hydroiodide	H_2O	*2.75*	14.5	11.79	(145)
$C_{11}H_{21}NO$	Formyl-*l*-menthylamine	AcOEt	*2.19*	10.5	−76.44	(145)
		$CHCl_3$	*5.25*	6	−83.78	
		MeOH	*7.44*	10	−83.43	
$C_{11}H_{21}NO$	Formyl-*d*-menthylamine	AcOEt	*1.83*	12	50.89	(145)
		$CHCl_3$	*5.39*	4	54.11	
		MeOH	*7.16*	11	63.30	
	From pulegone	$CHCl_3$	4.6		54.33	(1395)
$C_{12}H_{23}NO$	Acetyl-*l*-menthylamine	AcOEt	*2.16*	13	−76.27	(145)
		$CHCl_3$	*5.36*	10	−81.73	
		MeOH	*7.38*	10	−85.67	
	From pulegone	$CHCl_3$	4.9		−78.83	(1395)
$C_{12}H_{23}NO$	Acetyl-*d*-menthylamine	AcOEt	*1.77*	13	44.71	(145)
		$CHCl_3$	*4.40*	5	50.57	
		MeOH	*5.39*	10	48.80	
$C_{13}H_{25}NO$	Propionyl-*l*-menthylamine	AcOEt	*2.13*	13	−67.26	(145)
		$CHCl_3$	*5.09*	5	−76.53	
		MeOH	*8.93*	8	−78.02	
		EtOH	*2.6*	9	−76.02	
$C_{13}H_{25}NO$	Propionyl-*d*-menthylamine	AcOEt	*1.84*	12	40.45	(145)
		$CHCl_3$	*5.51*	8	45.14	
		MeOH	*7.19*	9	54.30	
$C_{14}H_{27}NO$	Butyryl-*l*-menthylamine	AcOEt	*2.22*	12	−63.58	(145)
		$CHCl_3$	*4.47*	4	−72.10	
	Butyryl-*d*-menthylamine	AcOEt	*1.78*	13.5	35.64	(145)
		$CHCl_3$	*4.88*	6	40.59	
$C_{24}H_{48}N_2O_6$	Di-*l*-menthylamine *d*-tartrate	MeOH	1.31	22.6	−12.58	(1586)
	Di-*l*-menthylamine *l*-tartrate	MeOH	1.31	20.7	−42.00	
	Di-*l*-menthylamine *dl*-tartrate	MeOH	1.31	22	−32.07	
$C_{46}H_{88}FeN_{10}$	*l*-Menthylammonium α-ferrocyanide	EtOH	1.080	17	−42.4	(247)
	l-Menthylammonium α-ferrocyanide	0.016% EtOH?	1.002	17	−34.2¶	
		AcOH?	1.044	17	−31.8¶	
	l-Menthylammonium β-ferrocyanide	EtOH	1.000	17	−28.5	

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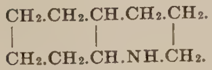
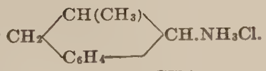
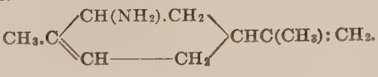
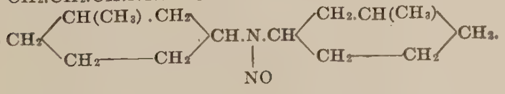
* 

† 

‡ 

§ 

‖ $(CH_3.C_6H_{10})_2N.CO.C_6H_5$. ¶ Mutarotation.

N-Menthyl carbamates: $C_{10}H_{19}.NH.COOR$

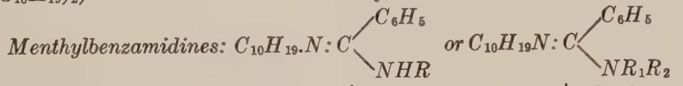
Formula	Name	Solvent	d, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{11}H_{21}NO_2$	*l*-Menthyl carbamate	EtOH	0.8		−81.6	(610)
$C_{12}H_{23}NO_2$	Methyl *l*-menthylcarbamate	CHCl₃	3.13	16	−74.29	(1514)
	($C_{10}H_{19}.NH.CO.OCH_3$)	MeOH	2.79	16	−76.11	
		CHCl₃	7.86	21	−77.67	(1631)
$C_{13}H_{25}NO_2$	Ethyl *l*-menthylcarbamate	CHCl₃	2.05	21	−69.43	(1514)
	($C_{10}H_{19}.NH.CO.OC_2H_5$)	EtOH	2.34		−67.39	
		CHCl₃	7.67	21	−71.98	(1631)
$C_{14}H_{25}NO_2$	Allyl *l*-menthylcarbamate	CHCl₃	8.02	21	−68.24	(1631)
$C_{14}H_{27}NO_2$	Propyl *l*-menthylcarbamate	CHCl₃	2.36	21	−68.56	(1631)
	Isopropyl *l*-menthylcarbamate	CHCl₃	1.95	21	−65.77	
$C_{15}H_{29}NO_2$	*n*-Butyl *l*-menthylcarbamate	CHCl₃	4.53	21	−64.85	(1631)
	Isobutyl *l*-menthylcarbamate	CHCl₃	1.87	21	−66.28	
$C_{17}H_{25}NO_2$	Phenyl *l*-menthylcarbamate	CHCl₃	5.23	19	−57.83	(1628)
$C_{18}H_{27}NO_2$	Benzyl *l*-menthylcarbamate	CHCl₃	7.55	21	−52.80	(1631)
		Py	5.20	19	−67.41	
$C_{18}H_{27}NO_2$	*o*-Tolyl *l*-menthylcarbamate	CHCl₃	4.07	19	−54.74	(1628)
		Py	4.17	19	−64.48	
	m-Tolyl *l*-menthylcarbamate	CHCl₃	4.72	19	−55.86	
		Py	5.70	19	−66.17	
	p-Tolyl *l*-menthylcarbamate	CHCl₃	3.42	19	−56.28	
		Py	3.74	19	−64.82	
$C_{18}H_{35}NO_2$	*n*-Heptyl *l*-menthylcarbamate	CHCl₃	6.78	21	−55.18	(1631)
$C_{19}H_{29}NO_2$	1, 3, 4-Xylyl *l*-menthylcarbamate	CHCl₃	3.02	19	−53.45	(1628)
		Py	3.94	19	−63.16	
	1, 2, 4-Xylyl *l*-menthylcarbamate	CHCl₃	3.58	19	−51.38	
		Py	2.79	19	−61.84	
	1, 2, 5-Xylyl *l*-menthylcarbamate	CHCl₃	2.18	19	−51.3	
		Py	2.34	19	−62.86	
$C_{19}H_{29}NO_2$	Phenylethyl *l*-menthylcarbamate	CHCl₃	4.66	21	−56.06	(1631)
$C_{19}H_{37}NO_2$	*n*-Octyl *l*-menthylcarbamate	CHCl₃	9.1	21	−52.10	(1631)
$C_{20}H_{29}NO_2$	Cinnamyl *l*-menthylcarbamate	CHCl₃	4.42	21	−49.62	(1631)
$C_{20}H_{31}NO_2$	Phenylpropyl *l*-menthylcarbamate	CHCl₃	3.43	21	−48.14	(1631)
$C_{21}H_{27}NO_2$	1-Naphthyl *l*-menthylcarbamate	CHCl₃	4.52	19	−51.52	(1628)
		Py	4.99	19	−63.45	
	2-Naphthyl *l*-menthylcarbamate	CHCl₃	4.25	19	−48.15	
		Py	5.20	19	−59.90	
$C_{21}H_{33}NO_2$	Carvacryl *l*-menthylcarbamate	CHCl₃	3.14	19	−46.64	(1628)
		Py	3.12	19	−57.58	
$C_{21}H_{33}NO_2$	Thymyl *l*-menthylcarbamate	CHCl₃	5.20	19	−45.48	(1628)
		Py	4.72	19	−56.29	
$C_{21}H_{37}NO_2$	*l*-Bornyl *l*-menthylcarbamate	EtOH	3.4		−71.04	(1629)
	dl-Isobornyl *l*-menthylcarbamate	EtOH	5		−55.8	(1629)
	d-Isobornyl *l*-menthylcarbamate	EtOH	2.67		1.41	
	l-Isobornyl *l*-menthylcarbamate	EtOH	2.64		−112.0	
$C_{27}H_{53}NO_2$	Cetyl *l*-menthylcarbamate	CHCl₃	4.88	21	−36.90	(1631)

Menthylcarbimide and carbamides: $C_{10}H_{19}N{:}CO$ *and* $C_{10}H_{19}.NH.CO.NH.R$ *or* $C_{10}H_{19}.NH.CO.NR_1R_2$

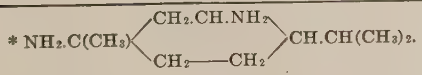
Formula	Name	Solvent	d, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{11}H_{19}NO$	*l*-Menthylcarbimide ($C_{10}H_{19}.N{:}CO$)	C₆H₆	2.22		−54.97	(1514)
		EtOH	24.5		−53.83	
$C_{13}H_{26}N_2O$	Ethyl-*l*-menthylcarbamide	CHCl₃	3.09	19	−69.16	(1620)
		Py	2.87	19	−70.23	
		EtOH	3.12	19	−73.77	
$C_{14}H_{28}N_2O$	*n*-Propyl-*l*-menthylcarbamide	CHCl₃	3.07	19	−66.03	(1628)
		Py	3.19	19	−66.88	
		EtOH	3.09	19	−70.08	
	Isopropyl-*l*-menthylcarbamide	CHCl₃	3.32	19	−64.76	
		Py	3.14	19	−65.22	
		EtOH	3.12	19	−67.42	
$C_{14}H_{26}N_2O$	Allyl-*l*-menthylcarbamide	CHCl₃	3.25	19	−65.33	(1628)
		Py	3.26	19	−68.05	
		EtOH	3.10	19	−70.11	
$C_{15}H_{30}N_2O$	Diethyl-*l*-menthylcarbamide	CHCl₃	3.23	19	−78.66	(1628)
		Py	3.09	19	−74.56	
		EtOH	3.19	19	−75.25	

Menthylcarbimide and carbamides: $C_{10}H_{19}N:CO$ and $C_{10}H_{19}.NH.CO.NH.R$ or $C_{10}H_{19}.NH.CO.NR_1R_2$.—(Continued)

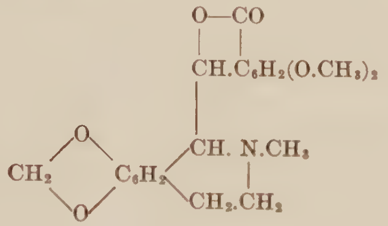
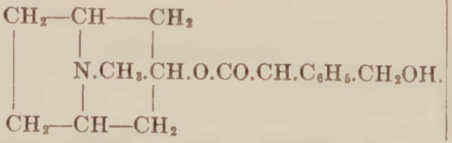
Formula	Name	Solvent	d, C or %	t, °C	[α]D	Lit.
$C_{15}H_{30}N_2O$	*n*-Butyl-*l*-menthylcarbamide	$CHCl_3$	3.08	19	−62.55	(1628)
		Py	3.03	19	−64.19	
		EtOH	3.05	19	−66.39	
	Isobutyl-*l*-menthylcarbamide	$CHCl_3$	2.78	19	−63.51	
		Py	3.14	19	−65.22	
		EtOH	3.08	19	−66.76	
	tert.-Butyl-*l*-menthylcarbamide	$CHCl_3$	1.24	19	−67.72	(1628)
		Py	1.23	19	−66.21	
		EtOH	3.50	19	−64.77	
$C_{16}H_{30}N_2O$	Piperidyl *l*-menthylcarbamide ($C_{10}H_{19}.NH.CO.N.C_5H_{10}$)	$CHCl_3$	2.0	19	−81.17	(1628)
		Py	1.91	19	−78.18	
		EtOH	2.67	19	−86.42	
$C_{18}H_{28}N_2O$	Benzyl-*l*-menthylcarbamide	$CHCl_3$	2.04	19	−51.47	(1628)
		Py	1.96	19	−59.26	
		EtOH	2.15	19	−56.80	
$C_{18}H_{28}N_2O$	*o*-Tolyl-*l*-menthylcarbamide	$CHCl_3$	1.67	19	−56.14	(1628)
		Py	2.40	19	−76.29	
		EtOH	2.65	19	−65.98	
	m-Tolyl-*l*-menthylcarbamide	$CHCl_3$	1.31	19	−68.15	
		Py	2.20	19	−81.59	
		EtOH	1.11	19	−75.51	
	p-Tolyl-*l*-menthylcarbamide	$CHCl_3$	0.991	19	−66.06	
		Py	2.82	19	−81.15	
		EtOH	2.86	19	−85.23	
$C_{21}H_{28}N_2O$	1-Naphthyl-*l*-menthylcarbamide	Py	1.06	19	−70.31	(1628)
	2-Naphthyl-*l*-menthylcarbamide	Py	1.66	19	−78.56	
		EtOH	1.51	19	−71.09	
$C_{21}H_{40}N_2O$	Di-*l*-menthylcarbamide ($CO(NH.C_{10}H_{19})_2$)	EtOH	1.65		−91.75	(1514)
		Py	1.83		−92.76	

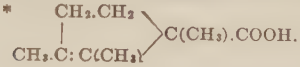

Menthylbenzamidines: $C_{10}H_{19}.N:C\begin{matrix}C_6H_5\\NHR\end{matrix}$ *or* $C_{10}H_{19}N:C\begin{matrix}C_6H_5\\NR_1R_2\end{matrix}$

Formula	Name	Solvent	d, C or %	t, °C	[α]D	Lit.
$C_{19}H_{30}N_2$	*l*-Menthylethylbenzamidine	$CHCl_3$	2.505	12	−112	(340)
$C_{21}H_{34}N_2$	*l*-Menthyldiethylbenzamidine	$CHCl_3$	1.9024	14	−172	(340)
$C_{23}H_{30}N_2$	Phenyl-*l*-menthylbenzamidine	$CHCl_3$	2.5360	12.5	−146	(340)
$C_{24}H_{32}N_2$	*o*-Tolylmenthylbenzamidine	$CHCl_3$	2.5056	14	−105	(340)
	m-Tolyl-*l*-menthylbenzamidine	$CHCl_3$	2.477	14	−142.5	
	p-Tolyl-*l*-menthylbenzamidine	$CHCl_3$	2.496	14	−132.5	
$C_{25}H_{34}N_2$	Phenyl-*l*-menthylethylbenzamidine	$CHCl_3$	1.4384	12	−392	(340)
		$CHCl_3$	2.504	12	−391	
		$CHCl_3$	2.9744	16	−60.5	
	DIAMINES					
$C_{10}H_{24}Cl_2N_2$	Aminotetrahydroumbellulylamine* dihydrochloride	EtOH	1.63		−21.41	(2046)
$C_{24}H_{28}N_2O_2$	Dibenzoylaminotetrahydroumbellulylamine	$CHCl_3$	2.15		117.3	(2046)
$C_{24}H_{32}N_2O_4$	Aminotetrahydroumbellulylamine dibenzoate	EtOH	1.69		−8.83	(2046)
	AMINO ACIDS					
	Ecgonine = Tropinecarboxylic acid; for pilosine, see pilocarpine, p. 420					
$C_7H_{11}NO_3$	Ecgoninic acid	H_2O	12.37		−43.2	(1245.5)
$C_9H_{14}ClNO_2$	Anhydroecgonine hydrochloride	H_2O			−61.5	(416.5); *cf.* (892)
$C_9H_{14}Br_3NO_2$	Anhydroecgonine dibromide hydrobromide	H_2O	3.06		30	(703)
$C_9H_{15}Br_2NO_2$	Hydrobromoanhydroecgonine hydrobromide	H_2O	1.25		42.3	(703)
$C_9H_{16}ClNO_3$	*d*-Ecgonine hydrochloride	H_2O	*4.4*		18.2	(417)
		H_2O			−57	(416.5)
$C_{10}H_{17}NO_3$	*d*-Ecgonine methyl ester	EtOH	*6.22*		22.5	(1247)
$C_{10}H_{19}NO_4.H_2O$	Ecgonine methohydroxide	H_2O	4.45	15	−42.4	(894)
$C_{11}H_{17}NO_2$	Anhydroecgonine ethyl ester		1.064^{21}_{4}	19	−48.4	(1246)
$C_{15}H_{26}ClNO_4$	Isovaleryl-*d*-ecgonine methyl ester hydrochloride	EtOH	2.01		25.4	(374)

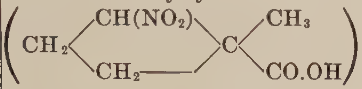

* $NH_2.C(CH_3)\begin{matrix}CH_2.CH.NH_2\\CH_2—CH_2\end{matrix}CH.CH(CH_3)_2$.

Ecgonine = Tropinecarboxylic acid; for pilosine, see pilocarpine, p. 420.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{19}H_{24}ClNO_4$	Cinnamyl-*d*-ecgonine methyl ester hydrochloride	EtOH	2.11		47.4	(374)
$C_{20}H_{27}NO_4$	Benzoyl-*l*-ecgonine methyl ester	$CHCl_3$	*9.925*	20	−16.35	(39)
		$CHCl_3$	*20.242*	20	−16.28	
$C_{20}H_{28}ClNO_4$	Benzoyl-*l*-ecgonine methyl ester hydrochloride		10	20	−66.399	(39)
$C_{20}H_{28}ClNO_4$	Benzoyl-*d*-ecgonine butyl ester hydrochloride	H_2O	2.5		46	(417.5)
$C_{21}H_{30}ClNO_4$	Benzoyl-*d*-ecgonine amyl ester hydrochloride	H_2O	2.2		38.6	(417.5)
	Cocaine = Methylbenzoylecgonine					
$C_{17}H_{21}NO_4$	Cocaine (free base)	50% EtOH	1.088		−35.4	(268); *cf.* (1945)
		$CHCl_3$	4.0		−15.75	
	(neutralized with dil. HCl)	H_2O	0.3569		−78.5	
	(neutralized with H_2SO_4)	H_2O	1.088		−81.8	
	(neutralized with H_2SO_4)	50% EtOH	1.088		−77.7	
$C_{17}H_{22}ClNO_4$	Cocaine hydrochloride	$CHCl_3$	2.0		−57.5	(268)
$C_{17}H_{22}ClNO_4$	Benzoyl-*d*-ecgonine methyl ester hydrochloride	EtOH	1.9		39.47	(417)
$C_{17}H_{22}ClNO_4$	Cocaine hydrochloride	H_2O	2	17	70.82	(957)
		H_2O	5	17	−69.83	
		H_2O	10	17	−67.80	
		H_2O	15	17	−65.77	
		H_2O	20	17	−64.00	
$C_{18}H_{23}NO_6$	Cocaine formate	H_2O	1	20	−54.67	(2071)
$C_{18}H_{24}ClNO_4$	Benzoyl-*d*-ecgonine ethyl ester hydrochloride	H_2O	2		40	(417)
$C_{19}H_{26}ClNO_4$	Benzoyl-*d*-ecgonine propyl ester hydrochloride	H_2O	2.6		46.2	(417)
	Hydrastine					
$C_{21}H_{21}NO_6$	Hydrastine	50% EtOH	0.204		115.0	(268)
		85% EtOH	0.2		37.5	
		93% EtOH	0.2		30.0	
		95% EtOH	0.4		0.0	
		97% EtOH	0.4		−12.5	
		100% EtOH	0.291		−49.8	
		$CHCl_3$	2.552	17	−57.8	(676)
		2*N* HCl	4.050	17	−127.3	
		50% Me_2CO	0.2		100.0	(268)
		Me_2CO	4.0		−85.0	
		$CHCl_3$	2.0		−63.8	
$C_{21}H_{22}ClNO_6$	Hydrastine hydrochloride	H_2O	1.647		197.0	(268)
		$CHCl_3$	2.0		8.52	
	Hyoscyamine = Isomer of atropine					
$C_{17}H_{23}NO_3$	*l*-Hyoscyamine ion neut. by					
	(a) H_2SO_4 (dil.)		4.015		32.6	(268)
	(b) H_2SO_3 (dil.)		4.009		32.4	
	(c) HCl (dil.)		4.0		32.4	
	(d) AcOH (dil.)		4.0		32.5	
		50% EtOH	4.0		21.0	(268)
	Neut. by H_2SO_4 (dil.)		4.0		31.25	
$C_{17}H_{23}NO_3$	*l*-Hyoscyamine	$CHCl_3$	4.0		−23.75	(268); *cf.* (31, 90)
		50% EtOH	4.0		−22.06	
		50% EtOH	20.0		−22.0	
	IID. The Molecule Contains an Asymmetric Atom Forming Part of a Ring and Attached to Four Other Carbon Atoms					
	ACIDS					
$C_9H_{14}O_2$	γ-Lauronolic acid		1.0177^{20}_{20}	20	145	(2026); *cf.* (234.5)
$C_9H_{14}O_2$	Lauronolic acid*		1.0133^{25}_{4}	25	187.7	(1516)

* 

ACIDS.—(*Continued*)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_9H_{14}O_3$	Camphononic acid*	C_6H_6	2.4	27.5	17.8	(1519)
		EtOH	3.0	28	−3.9	
$C_9H_{15}NO$	Lauronolic amide	ligroin	1	25	94.6	(1516)
$C_{11}H_{20}O_3$	Ethyl hydroxylauronate		1.100_4^{20}	33.5	6.73	(1520)
$C_{10}H_{15}N$	β-Fencholenic nitrile		$0.9203_{15.6}^{15.6}$	15.6	43.66	(334.5)
$C_{10}H_{16}O_2$	β-Fencholenic acid†	EtOH			19.64	(1922)
IIDB. The Molecule Contains Two or More Asymmetric Atoms Attached Respectively to Two and Four Other Carbon Atoms						
ACIDS						
$C_6H_9NO_4$	2-Nitro-1-methylcyclobutanecarboxylic acid 	EtOH(?)		25	−87.31	(1692)
$C_9H_{13}NO_4$	Nitrosocampholactone	EtOH	5.5		−85.4	(1521)
$C_9H_{14}O_2$	*cis*-Camphonololactone‡	EtOH	10	26	22.3	(1519)
$C_9H_{14}O_2$	Isocampholactone	EtOH	8.8	28	−63.1	(1519)
$C_9H_{14}O_2$	Campholytolactone	EtOH	12		8.5	(1527)
$C_9H_{16}O_3$	*cis*-Camphonolic acid	EtOH	10	28	29.2	(1519)
$C_9H_{16}O_3$	*l-trans*-3-Hydroxy-1, 5, 5 trimethylcyclopentane-1-carboxylic acid§	EtOH	3.29	27	−10.3	(1956)
AMINO ACIDS						
$C_9H_{14}N_2O_2$	Nitrosoaminocamphoranic anhydride	EtOH	2.5	24	153	(1528)
$C_9H_{15}NO$	Aminocamphonanic anhydride¶	EtOH	10	29	−60.5	(1528)
		H_2O	0.5	28	−60.6	
$C_9H_{17}ClNO_2$	Aminolauronic acid hydrochloride	H_2O	1.437	18	26.1	(2159)
		EtOH	1.335	18	26.6	
$C_9H_{17}NO$	Aminodihydrocampholytic acid‖	ligroin	10.0	30	72.8	(1527)
$C_9H_{17}NO_2$	Aminocamphonanic acid**	H_2O	10	25	−29.2	(1528)
$C_{10}H_{20}NClO_2$	Methyl *d-cis*-3-amino-1, 2, 2-trimethylcyclopentanoate hydrochloride††	H_2O	4.0		20.4	(1956)
		EtOH	10		29.2	
$C_{11}H_{17}NO_2$	Acetylaminocamphonanic anhydride‡‡	EtOH	10.88		72.7	(1528)
$C_{11}H_{17}NO_3$	*n*-Anhydrocarboxymethylaminolauronic acid	H_2O	1.465	14	−22.2	(2159)
		EtOH	1.503	14	−11.6	
		C_6H_6	1.239	14	−22.2	
$C_{11}H_{19}NO_4$	Carboxymethylaminolauronic acid	H_2O	1.445	18	45.7	(2159)
$C_{16}H_{19}NO_2$	*n*-Anhydrobenzoylaminolauronic acid	EtOH	1.476	18	−69.1	(2159)
$C_{16}H_{21}NO_3$	Benzoylaminolauronic acid	EtOH	1.115	20	−18.4	(2159)
$C_{17}H_{23}NO_4$	Methyl benzoylaminolauronate	EtOH	1.453	19	−28.9	(2159)
		H_2O		19	−18.4	(2159.5)
IIDC. The Molecule Contains Two or More Asymmetric Atoms Attached Respectively to Three and Four Other Carbon Atoms						
HYDROCARBONS AND THEIR HALOGEN AND NITROGEN DERIVATIVES						
$C_{10}H_{13}Br_2NO_3$	1, 2-Dibromo-1-nitrocamphane	C_6H_6	1.98	19	4.2	(578)
$C_{10}H_{15}NO_2$	1-Nitrocamphene	EtOH	2.02	21	112.0	(578)
		C_6H_6	4.00	21	137.5	
$C_{10}H_{16}$	Camphene	C_6H_6	16.38	20	62.59	(257)
$C_{10}H_{16}$	Bornylene	C_6H_6	8.98	20	−22.27	(849)
$C_{10}H_{16}BrNO_2$	1, 1-Bromonitrocamphane	EtOH	2.0		−53.8	(577)
$C_{10}H_{16}BrNO_2$	2-Bromo-1-nitrocamphane	C_6H_6	2.04	21	3.7	(578)
$C_{10}H_{16}Cl_2$	1, 1-Dichlorocamphane	AcOEt	22.34		−16	(1979)
$C_{10}H_{16}ClNO_2$	1, 1-Chloronitrocamphane	EtOH	2.04	21	−53.1	(577)
		C_6H_6	2.04	21	71.9	
$C_{10}H_{16}INO_2$	1, 1-Iodonitrocamphane	EtOH	1.0	19	−10.8	(577)
		C_6H_6	2.0	20	−15.0	
$C_{10}H_{16}INO_2$	2-Iodo-1-nitrocamphane	EtOH	1.42	20	−35.1	(578)
		C_6H_6	1.47	20	−29.4	
$C_{10}H_{17}NO_2$	1-Nitrocamphane	EtOH	2.404	20	4.6	(577)
		C_6H_6	2.0	20	20.4	
	Pseudonitrocamphane	KOH.EtOH	2.2		4§§	

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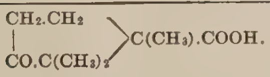
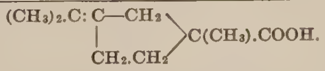
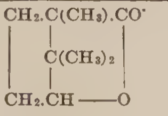
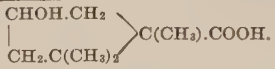
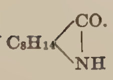
* 
$\begin{matrix}CH_2.CH_2\\ |\\ CO.C(CH_3)_2\end{matrix} > C(CH_3).COOH.$

† 
$\begin{matrix}(CH_3)_2.C{:}\,C{-}CH_2\\ |\\ CH_2.CH_2\end{matrix} > C(CH_3).COOH.$

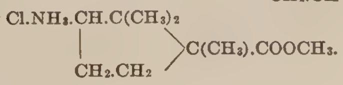
‡ 
$CH_2.C(CH_3).CO$, $C(CH_3)_2$, $CH_2.CH{-}O$

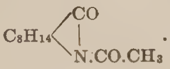
§ 
$\begin{matrix}CHOH.CH_2\\ |\\ CH_2.C(CH_3)_2\end{matrix} > C(CH_3).COOH.$

‖ $NH_2.C_8H_{14}.COOH.$

¶ 
$C_8H_{14}\begin{matrix}CO.\\ |\\ NH\end{matrix}$

** $HO.CO.C_8H_{14}.NH_2.$

†† 
$\begin{matrix}Cl.NH_3.CH.C(CH_3)_2\\ |\\ CH_2.CH_2\end{matrix} > C(CH_3).COOCH_3.$

‡‡ 
$C_8H_{14}\begin{matrix}CO\\ |\\ N.CO.CH_3\end{matrix}.$

§§ Mutarotation.

HYDROCARBONS AND THEIR HALOGEN AND NITROGEN DERIVATIVES.—*(Continued)*

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{18}$	Isocamphane (from camphene)		0.846^{19}	17	0	(959)
	(from borneol)	EtOH	*8.76*	17	−8.5	
	(from isoborneol)	EtOH	*8.51*	17	2.81	
	(from camphor)	EtOH	*4.688*		−3.95	
$C_{10}H_{18}$	Thujane ((1) from *l*-α-thujene)		0.8139	20	62.03	(311)
	((2) from *d*-β-thujene)		0.8191	20	34.72	
	((3) from sabinene)		0.819	20	18.6	
$C_{11}H_{16}N_2O$	*d*-Limonene α-nitrosocyanide	$CHCl_3$	2.27	18.5	152.7	(1179)
	d-Limonene β-nitrosocyanide	$CHCl_3$	1.87	19	−31.6	
$C_{11}H_{18}$	Homofenchene	Et_2O	*41.9*	17	23.06	(2131)
$C_{17}H_{21}NO_3$	Benzoyl-ψ-nitrocamphane	EtOH	2.0	21	−19.3	(577)
$C_{20}H_{34}$	Hydrodifenchene		0.9652^{17}	18	1.14	(1124)

ALCOHOLS

Monohydric Alcohols Other Than Borneol

For thujol, *see* p. 454

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{16}O$	α-Hydroxycamphene	EtOH	4.02	19	34.1	(578)
		C_6H_6	2.12	20	29.5	
$C_{10}H_{16}O$	Teresantalol	EtOH			11.97	(1925)
$C_{10}H_{20}O$	α, β, β, γ-Tetramethylcyclopentane-α-carbinol	C_6H_6		20	67.18	(1818, 1832)
$C_{12}H_{20}O$	β, β-Dimethylnorcamphane-γ-spirocyclopropanemethylol	EtOH	1.496	20	26.79	(257)
$C_{12}H_{22}O$	Ethylcamphol	EtOH			37.0	(813)

Dihydric Alcohols and Other Dihydroxy Compounds

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{16}O_2$	*l*-Campherol (hydroxycamphor)*	EtOH	3.34		−32.93	(1357.5)
$C_{10}H_{18}O_2$	α, β-Camphorglycol†	EtOH	9.97		12.3	(1368)
$C_{11}H_{22}O_2$	Homocamphoricglycol‡	EtOH	5.55	21	81.08	(1553)
$C_{12}H_{22}O_2$	α, β-Dimethylcamphanediol	EtOH	1.22		0.95	(587)
$C_{13}H_{22}O_2$	9-Methyl-3-isopropenyldicyclononan-5, 7-diol (solid)	EtOH	7.88	19	−19.35	(1758)
	(liquid)	EtOH	7.42	15	11.75	
$C_{15}H_{26}O_4$	Homocamphoricglycol diacetate	EtOH	13.4	21	52.6	(1553)
$C_{25}H_{30}O_4$	Homocamphoricglycol dibenzoate	EtOH	9.23	21	34.68	(1553)

ALDEHYDES AND KETONES

Aldehydes and Ketones Not Related Directly to Terpenes

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{18}O$	1, 2, 2, 3-Tetramethylcyclopentane-1-aldehyde§	C_6H_6		20	89.26	(1832, 1835)
$C_{11}H_{20}O$	1, 2, 2, 3-Tetramethylcyclopentane-1-methyl ketone			20	63.67	(1818, 1832)
$C_{12}H_{22}O$	1, 2, 2, 3-Tetramethylcyclopentane-1-ethyl ketone			20	63.15	(1818, 1832)
$C_{13}H_{20}O_2$	9-Methyl-3-isopropenyldicyclononan-5-ol-7-one	EtOH	7.07	15	18.8	(1758)
$C_{16}H_{22}O$	1, 2, 2, 3-Tetramethylcyclopentane-1-phenyl ketone			20	−1.21	(1818, 1832)
$C_{16}H_{24}O$	β, α′-Dimethyl-α, α, α′-triallylcyclopentanone‖		0.9179	20	73.11	(808)
$C_{16}H_{30}O$	α, β-Dimethyl-α, α, α′-tripropylcyclopentanone			17	7.10	(809)
$C_{17}H_{24}O$	1, 2, 2, 3-Tetramethylcyclopentane-1-benzyl ketone			20	32.16	(1832)
$C_{18}H_{24}O$	1, 2, 2, 3-Tetramethylcyclopentane-cinnamyl ketone			20	54.29	(1832)
$C_{18}H_{26}O$	1, 2, 2, 3-Tetramethylcyclopentane-1, 2-phenylethyl ketone			20	18.96	(1832)
$C_{20}H_{24}O$	1, 2, 2, 3-Tetramethylcyclopentane-1, 1-naphthyl ketone	C_6H_6	*10*	20	−60.52	(1832)

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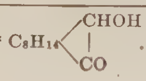
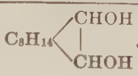
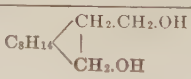
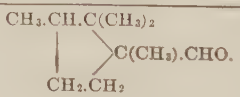
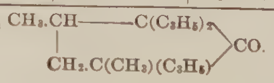
* 
$C_8H_{14}\left\langle\begin{array}{l}CHOH\\ \quad|\\ CO\end{array}\right.$.

† 
$C_8H_{14}\left\langle\begin{array}{l}CHOH\\ \quad|\\ CHOH\end{array}\right.$.

‡ 
$C_8H_{14}\left\langle\begin{array}{l}CH_2.CH_2.OH\\ \quad|\\ CH_2.OH\end{array}\right.$.

§ 
$\begin{array}{l}CH_3.CH.C(CH_3)_2\\ \quad\;|\qquad\quad\rangle C(CH_3).CHO.\\ CH_2.CH_2\end{array}$

‖ 
$\left.\begin{array}{l}CH_3.CH\text{——}C(C_3H_5)_2\\ \quad|\\ CH_2.C(CH_3)(C_3H_5)\end{array}\right\rangle CO.$

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
	FENCHONE AND DERIVATIVES					
$C_{10}H_{14}O_2$	Diketofenchane	C_6H_6	*14.2*	15.5	75.78	(233)
$C_{10}H_{15}BrO$	Bromofenchone		1.348^{12}_{12}	12	8.61	(360)
$C_{10}H_{15}BrO$	Bromoisofenchone	EtOH	*2.42*	15	−164.1	(2130)
$C_{10}H_{16}O$	*d*-Fenchone*		0.9442^{20}_4	17	63.01	(1858); *cf.* (58)
	l-Fenchone		0.9402^{20}_4	15.5	−51.24	
$C_{10}H_{17}N$	Fenchoneimine		$0.9322^{11.5}$	19.5	76.30	(1359)
$C_{10}H_{17}NO$	Fenchone oxime	EtOH	*1.14*	10	65.94	(2108)
		AcOEt	2.72	14.5	52.61	(145)
$C_{11}H_{19}N_3O$	*l*-Fenchone semicarbazone	MeOH	*8.11*	20	47.04	(2131)
$C_{11}H_{19}N_3O$	Isofenchone semicarbazone	MeOH	*1.25*	11	−8.27	(2130)
	THUJONE AND DERIVATIVES					
$C_{10}H_{16}O$	α-Thujone†		0.9190^{15}		−29.90	(726); *cf.* (1918)
	β-Thujone; *cf.* (306, 2114)		0.924	12	67.4	(2022); *cf.* (306, 2114)
$C_{10}H_{17}NO$	β-Thujoneoxime	MeOH	*19.90*	11	105.1	(1131)
$C_{11}H_{18}O$	Methylthujone		0.9102	15	16.27	(796)
$C_{11}H_{19}N_3O$	α-Thujone semicarbazone	MeOH	*4.99*	22	59.83	(1131)
	β-Thujone semicarbazone	MeOH	*6.29*	21	223.67	
$C_{12}H_{20}O$	Dimethylthujone		0.916	15	−19.45	(801)
$C_{12}H_{20}O$	Ethylthujone		0.9155	15	−48.37	(801)
$C_{13}H_{20}O$	Allylthujone		0.9254	15	−57.78	(297)
$C_{13}H_{22}O$	Propylthujone		0.9102	15	−48.47	(297)
$C_{18}H_{20}O_3$	Piperonylidenethujone	EtOH	2.36	15	−765	(297)
$C_{18}H_{22}O_2$	Anisylidenethujone	EtOH	2.89	15	−829.00	(297)
	EPICAMPHOR AND DERIVATIVES					
$C_{10}H_{15}BrO$	Bromo-*l*-epicamphor	AcOEt	3.62	19	−86.6	(237)
$C_{10}H_{15}NO_2$	α-Isonitrosoepicamphor	C_6H_6	4.00	19	−201.9	(237)
	β-Isonitrosoepicamphor	C_6H_6	5.10	19	−183.5	
	α-Isonitrosoepicamphor	$CHCl_3$	1.020		196.1‡	(608); *cf.* (236)
	β-Isonitrosoepicamphor	$CHCl_3$	1.045		191.4‡	
$C_{10}H_{15}NO_2$	Isonitrosoepicamphor (stable)	$CHCl_3$	1.0	170	−200.1	(589)
		2% NaOH	1.0	170	−422.0	
		$CHCl_3$	1.0	137	−179.0	
	(unstable)	2% NaOH	1.0	137	288.0	
$C_{10}H_{16}O$	*l*-Epicamphor§	C_6H_6	13.12	19	−58.21	(237)
$C_{10}H_{17}NO$	*l*-Epicamphoroxime	C_6H_6	6.29	19	100.8	(237)
$C_{11}H_{17}NO_2$	α-Isonitrosoepicamphor-*o*-methyl ether	$CHCl_3$	1.054		−201.5	(608)
	β-Isonitrosoepicamphor-*o*-methyl ether	$CHCl_3$	1.046		−173.6	
$C_{11}H_{18}O_3$	*l*-Epiborneolcarboxylic acids (A, M. P. 125°)	AcOEt	4.64	19	2.36	(237)
	(B, M. P. 145°)	AcOEt	5.52	19	−4.8	
	(C, M. P. 173°)	AcOEt	1.09	19	15.2	
	(D, M. P. 237°)	AcOEt	0.69	19	77.9	
$C_{16}H_{21}N_3O$	α- (β-)Isonitrosoepicamphor phenylhydrazone	EtOH	1.139		142	(608)
		$CHCl_3$	1.139		259.2	
$C_{17}H_{19}NO_3$	Benzoyl-α-isonitrosoepicamphor	$CHCl_3$	1.045		128.7	(608)
	Benzoyl-β-isonitrosoepicamphor	$CHCl_3$	1.036		130.0	
$C_{17}H_{20}N_2O_3$	β-Isonitrosoepicamphor phenylurethane	$CHCl_3$	1.026		−124.3	(608)
	α-Isonitrosoepicamphor phenylurethane	$CHCl_3$	0.236		−110.2	
	CAMPHOR AND DERIVATIVES					
	Camphor and hydroxy, alkyl and alkylidene derivatives					
$C_{10}H_{16}O$	Camphor‖	PhMe	4.494	20	43.45	(306)
		90% EtOH	10		43.0	(630)
		90% EtOH	10		39.66	
		60% EtOH	2.5		32.32	
		C_6H_6	4		40.62	
		olive oil	10		53.15	

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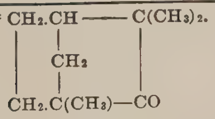
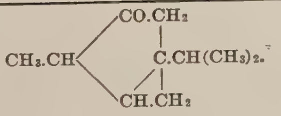
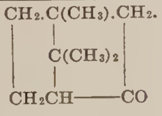
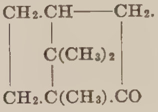
* 

† 

‡ Mutarotation.

§ 

‖ 

Camphor and hydroxy, alkyl and alkylidene derivatives.—(*Continued*)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{16}O$	Camphor.—(*Continued*)	$C_2H_4Cl_2$	*50.58*	11.7	51.94	(1599)
		$C_2H_4Cl_2$	*52.68*	15.7	52.68	
	l-Camphor	EtOH	20.13	20	−41.45	
$C_{10}H_{16}O_2$	β-Hydroxycamphor	EtOH	9.57		12.3	(1368)
	α-Hydroxycamphor	EtOH	9.45		12.8	
$C_{11}H_{15}NO_3$	Nitromethylenecamphor	$CHCl_3$	0.980		88	(613)
		12% Na-EtOH	0.980		0*	
		10% NaOH	0.988		36.6*	(613)
$C_{11}H_{16}O$	Methylenecamphor	EtOH			127.5	(1431.5)
$C_{11}H_{17}NO_2$	α, α-Nitromethylenehydroxycamphor	$CHCl_3$	1.0400		−159.5	(613)
$C_{11}H_{18}O$	α-Methoxycamphor		0.9314^{20}_{20}	20	−27.31	(582)
		C_6H_6	2.00	20	−24.5	
$C_{11}H_{18}O$	α-Methylcamphor	EtOH	5	25	30	(723); *cf.* (1429)
$C_{12}H_{18}O$	Ethylidenecamphor	EtOH			113	(1433)
$C_{12}H_{20}O$	Ethylcamphor	EtOH	27.9	15	45.48	(1281); *cf.* (813, 1433)
$C_{12}H_{20}O$	Dimethylcamphor		0.9471^{25}_{4}	24	92.7	(805)
$C_{13}H_{20}O$	Allylcamphor	EtOH	10.0	14	79.62	(1281)
$C_{13}H_{22}O$	Propylcamphor	EtOH	9.89	15	60.95	(1281); *cf.* (813, 823)
$C_{13}H_{22}O$	Methylethylcamphor	EtOH	2.01	16	98.65	(1281)
		EtOH		18	99.4	(813)
$C_{14}H_{24}O$	Diethylcamphor	EtOH		15	91.21	(813)
		EtOH	7.44	15	91.35	(1281)
$C_{14}H_{24}O$	Isobutylcamphor	EtOH			72.4	(823)
$C_{16}H_{24}O$	Diallylcamphor	EtOH	16.1	17	152.37	(1281)
$C_{16}H_{28}O$	Dipropylcamphor	EtOH	8.28	17	54.35	(1281); *cf.* (813)
$C_{17}H_{19}BrO$	*o*-Bromobenzylidenecamphor	PhMe			283	(820)
	p-Bromobenzylidenecamphor	PhMe			315	
$C_{17}H_{19}ClO$	Phenylchloromethylenecamphor	C_6H_6	1.00	20	−217	(584)
$C_{17}H_{19}NO_3$	*o*-Nitrobenzylidenecamphor	$CHCl_3$			50	(2212)
	m-Nitrobenzylidenecamphor	$CHCl_3$	4.67		311	
	p-Nitrobenzylidenecamphor	$CHCl_3$	1.5510		437	
$C_{17}H_{20}O_2$	Salicylidenecamphor	EtOH	0.845	23	469	(804)
		0.1*N* KOH	3.27		820	
$C_{17}H_{20}O_2$	*m*-Hydroxybenzylidenecamphor	EtOH	0.859	23	423	(804)
		0.1*N* KOH	0.436	19	507	
	p-Hydroxybenzylidenecamphor	EtOH	0.852	23	500	
		0.1*N* KOH	0.450	22	770	
$C_{17}H_{22}O$	Benzylcamphor	EtOH	6.23	14	149.10	(1281); *cf.* (813)
$C_{18}H_{19}NO$	Phenylcyanomethylenecamphor	$CHCl_3$	1.0432		246	(613)
$C_{18}H_{21}NO_2$	Phenylcarboxamidemethylenecamphor	$CHCl_3$	1.044		281.1	(613)
$C_{18}H_{22}O_2$	Piperonylidenecamphor	PhMe	*8.11*	20	133.74	(824)
$C_{18}H_{22}O_2$	*o*-Methoxybenzylidenecamphor	PhMe			431.5	(792)
	p-Methoxybenzylidenecamphor	PhMe			467.07	
$C_{18}H_{24}O$	*m*-Tolylidenecamphor	EtOH	0.858	24	396	(804)
		EtOH	0.815	23	458	
$C_{18}H_{24}O_2$	*m*-Methoxybenzylcamphor	PhMe	*6.207*	20	127.36	(824)
	p-Methoxybenzylcamphor	PhMe	*7.77*	20	95.43	
$C_{19}H_{22}O$	Cinnamylidenecamphor	C_6H_6	*10.07*	20	269.74	(1827)
		$CHCl_3$	*10.10*	20	296.11	
$C_{19}H_{24}O$	β, β-Phenylmethylethylidenecamphor	EtOH	4.84	15	126.1	(1557)
$C_{19}H_{26}O$	β, β-Phenylmethylethylcamphor	EtOH	7.34	15	39.23	(1557)
$C_{19}H_{26}O$	γ-Phenylpropylcamphor	$CHCl_3$	*10.2*	20	66.53	(1827)
$C_{19}H_{26}O$	Ethylbenzylcamphor	EtOH	8.27	19	90.62	(1281); *cf.* (813)
		EtOH	6.81	19	91.50	
$C_{19}H_{26}O_2$	Ethylsaligenylcamphor	PhMe	*6.59*	20	102.69	(824)
$C_{20}H_{26}O$	β, β-Phenylethylethylidenecamphor	EtOH	2.53	15	122.28	(1557)
$C_{20}H_{28}O$	β, β-Ethylphenylethylcamphor	EtOH	9.28	15	31.37	(1557)

* Mutarotation.

Camphor and hydroxy, alkyl and alkylidene derivatives.—(Continued)

Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{20}H_{28}O$	Cuminylcamphor	PhMe	*6.506*	20	89.25	(824)
$C_{20}H_{30}O$	Bornylenecamphor	EtOH			69.2	(763)
$C_{21}H_{28}O$	β, β-*n*-Propylphenylethylidenecamphor	EtOH	2.77	15	127.20	(1557)
		EtOH	3.05	15	126.75	
	β, β-Isopropylphenylethylidenecamphor	EtOH	5.04	15	115.35	
$C_{21}H_{30}O$	β, β-*n*-Propylphenylethylcamphor	EtOH	8.47	15	35.80	(1557)
	β, β-Isopropylphenylethylcamphor	EtOH	8.65	15	27.65	
$C_{23}H_{24}O$	Diphenylmethylenecamphor	EtOH			287	(803)
$C_{23}H_{26}O_2$	β-Ethoxy-α-naphthylidenecamphor	EtOH	*5.32*		121.13	(847)
$C_{24}H_{28}O$	Dibenzylcamphor	EtOH	1.63	20	102.12	(1281); *cf.* (813)
$C_{38}H_{46}O_2$	*trans*-Diphenylpropylenedicamphor	$CHCl_3$	*10.2*	20	40.63	(1827)
	cis-Diphenylpropylenedicamphor	$CHCl_3$	*10.1*	20	30.22	
	Imines, oximes and hydrazones of camphor, etc.					
$C_{10}H_{16}BrNO$	β-Bromocamphoroxime ($C_{10}H_{15}Br:NOH$)	$CHCl_3$	2.0	21	−73.5	(582)
$C_{11}H_{19}NO$	α-Methylcamphoroxime	EtOH	5	20	30.3	(723)
	Methylcamphoroxime	EtOH	4.88	22	25.15	
$C_{11}H_{19}N_3O_2$	*l*-Campherol semicarbazone	EtOH	8.45	17	−5.91	(1406); *cf.* (1358)
$C_{12}H_{19}NO$	Acetylcamphorimine*	$CHCl_3$	1.07		263.2	(602)
$C_{12}H_{21}NO$	Ethylcamphoroxime	EtOH	3.03	13	46.17	(1281); *cf.* (813)
$C_{13}H_{21}NO$	Allylcamphoroxime	EtOH	2.52	14	55.88	(1281)
$C_{13}H_{23}NO$	Propylcamphoroxime	EtOH	8.09	15	53.98	(1281)
$C_{17}H_{20}BrNO_2$	β-Benzoyl-β-bromocamphoroxime	$CHCl_3$	2.02		−39.2	(582)
$C_{17}H_{22}N_2O$	Camphor benzoylhydrazone†	$CHCl_3$	1.516		−50.5	(612)
$C_{18}H_{24}N_2O_2$	Methylcamphoroxime phenylurethane	EtOH	3.67	22	25.3	(806)
$C_{24}H_{28}N_4O_3$	Camphoroximephenylcarbamate phenylcarbamide	EtOH	1.04	15	−56.6	(1173)
	Halogen derivatives of camphor, methylcamphor and benzylcamphor					
$C_{10}H_{13}Br_2ClO$	α, β-Dibromo-α-chlorocamphor	$C_2H_4Cl_2$	*36.67*	13.0	43.02	(1599)
$C_{10}H_{13}Br_3O$	α, α′, β-Tribromocamphor	Me_2CO	2.42	9	2	(41)
$C_{10}H_{13}ClO$	Trichlorocamphor	EtOH	*4.57*		51.2	(272)
$C_{10}H_{14}BrClO$	α, α′-Chlorobromocamphor	$CHCl_3$			62.4	(272.5)
	α, β-Chlorobromocamphor	$CHCl_3$			40.8	
$C_{10}H_{14}Br_2O$	α, α′-Dibromocamphor	$C_2H_4Cl_2$	34.29	15.5	42.07	(1599)
	α, β-Dibromocamphor	$C_2H_4Cl_2$	25.81	14.9	104.17	(261)
		Me_2CO	5		127‡	
		EtOH	2.35		120‡	
		C_6H_6	16.23		101‡	
$C_{10}H_{14}Br_2O$	α′, β-Dibromocamphor	Me_2CO	5		85‡	
		EtOH	0.6		73‡	
		C_6H_6	16.14		83‡	
	α, π-Dibromocamphor	AcOH	1		135.0‡	
		AcOEt	5		128.9‡	
		EtOH	0.66		128.1‡	
		Me_2CO	5		128.2‡	
		Me_2CO	7.5		128.3‡	
		$CHCl_3$	10		125.9‡	
		$CHCl_3$	2		126.4‡	
		$C_2H_4Br_2$	5		140.9‡	
		PhMe	5		108.4‡	
		C_6H_6	14.75		110.8‡	
$C_{10}H_{14}Br_2O$	α′, π-Dibromocamphor	AcOH	1		99.0‡	
		AcOEt	5		108.6‡	
		EtOH	0.66		109.0‡	
		Me_2CO	5		111.7‡	
		$CHCl_3$	10		118.6‡	
		$CHCl_3$	2		119.5‡	
		$C_2H_4Br_2$	5		120.0‡	

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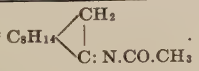
* 
$C_8H_{14}\langle{}^{CH_2}_{C:N.CO.CH_3}$.

† $C_{10}H_{16}:N.NH.COC_6H_5$.

‡ $[\alpha]_{5641}$.

Halogen derivatives of camphor, methylcamphor and benzylcamphor.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{14}Br_2O$	α′, π-Dibromocamphor.—(*Continued*)	PhMe	5		120.9*	(261)
		C_6H_6	5.63		126.6*	
$C_{10}H_{14}Cl_2O$	α, α′-Dichlorocamphor	EtOH			45.8	(270.5)
		EtOH			48.5	
		$CHCl_3$			45.9	
	α, β-Dichlorocamphor	EtOH			48.5	
		$CHCl_3$			45.9	
$C_{10}H_{14}I_2O$	Diiodocamphor	$CHCl_3$	*2.8*		28	(1393)
$C_{10}H_{15}BrO$	α-Bromocamphor	$C_2H_4Cl_2$	*43.75*	12.4	145.3	(1599)
		EtOH	9.96	20	134.8	(2100)
		EtOH	0.514	20	137.1	
		Et_2O	9.76	20	136.3	
		Et_2O	0.923	20	138.8	
		Me_2CO	7.72	20	141.5	
		Me_2CO	0.529	20	140.0	
		AcOEt	8.69	20	139.7	
		AcOEt	0.555	20	139.6	
		C_6H_6	10.17	20	120.5	
		C_6H_6	0.472	20	120.7	
		EtOH	5		164.75*	(1330)
	α′-Bromocamphor	EtOH	5		−38.1	
	Equilibrium mixture, $\alpha \rightleftharpoons \alpha'$	KOH.EtOH	5		147.8	
	l-Bromocamphor	C_6H_6	1.67		117.1	(1667)
	d-Bromocamphor	C_6H_6	1.66		−118.2	
	β-Bromocamphor; *cf.* (280, 780, 1390, 1449, 2172.5)	$CHCl_3$	2.01	20	16.3	(582)
		EtOH	2.01	20	19.1	
		Me_2CO	3.33	14	19.2	(41)
$C_{10}H_{15}ClO$	α-Chlorocamphor	$C_2H_4Cl_2$	*32.02*	12.4	106.5	(1599)
		EtOH	*5*		95.8	(1285); *cf.* (271, 279)
$C_{11}H_{17}BrO$	Methylbromocamphor	EtOH			176.8	(1431.5)
	Bromomethylcamphor	EtOH			150.5	
$C_{11}H_{17}BrO$	α-Bromo-α-methylcamphor	EtOH	5	20	184.4	(723)
	ω-Bromo-α-methylcamphor	EtOH	5	20	155.4	
	β-Bromo-α-methylcamphor	EtOH	1.72	25	18.8	
$C_{17}H_{21}BrO$	Benzylbromocamphor (form a)	EtOH			61	(820)
	(form b)	EtOH			20	
Nitro derivatives of camphor						
$C_{10}H_{13}Br_2NO_3$	α, β-Dibromo-α′-nitrocamphor	Me_2CO	4.74	10	−25.7	(41)
$C_{10}H_{14}BrNO_3$	Bromonitrocamphor	EtOH	1		−21.7	(271.5); *cf.* (1306)
$C_{10}H_{14}ClNO_3$	α, α′-Chloronitrocamphor	$C_2H_4Cl_2$	43.80	12.8	6.92	(1599)
$C_{10}H_{13}BrNO_3K.2H_2O$	Potassium pseudonitrobromocamphor	H_2O	4.68	12	91	(1286.5)
$C_{10}H_{15}NO_3$	α-Nitrocamphor	$C_2H_4Cl_2$	*49.87*	12.0	19.47†	(1599)
$C_{20}H_{28}N_2O_5$	Anhydro-ψ-nitrocamphor	$C_2H_4Cl_2$	*15.96*	14.9	132.84	(1599)
Cyano derivatives of camphor and of alkyl camphors						
$C_{11}H_{15}NO$	Cyanocamphor	PhMe			44.68	(779, 790)
		C_6H_6	4.12		0	(822)
		PhMe	4.12		4.03	
		p-Xylene	4.12		3.03	
		EtOH	4.12		12.16	
		MeCN	2.70		27.92	
		EtCN	2.66		28.58	
		MeI	4.12		37.3	
		PrI	4.12		36.6	
		CH_2O_2	4.12		42.4	
		AcOH	4.12		45.4	
		iso-$PrCO_2H$	4.12		48.4	
$C_{12}H_{17}NO$	α-Methylcyanocamphor				150.8	(818); *cf.* (786)
	β-Methylcyanocamphor				90.1	

* $[\alpha]_{5461}$. † Mutarotation.

Cyano derivatives of camphor and of alkyl camphors.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{14}H_{19}NO$	Cyano-*C*-allylcamphor	PhMe			49	(793)
	Cyano-*O*-allylcamphor	PhMe			124	
$C_{14}H_{21}NO$	Cyano-*O*-propylcamphor	EtOH			126	(793)
	Cyano-*C*-propylcamphor	EtOH			90	
Sulfur derivatives of camphor: Sulfides, sulfoxides, etc.						
$C_{10}H_{16}OS$	Camphor-β-thiol	Me_2CO	10	11	6	(1301)
$C_{10}H_{16}O_2S$	Camphor-β-sulfinic acid	H_2O	2.0	20	−74.50	(907, 1968)
	Sodium salt	H_2O	0.885	19	−58.2	(1968)
	Zinc salt	H_2O	4.00	19	−33.8	(1968)
$C_{10}H_{16}O_3S_2$	Camphor β-thiosulfonate	H_2O	5.0	16.5	11.52	(907)
$C_{10}H_{16}S$	Thiocamphor	AcOEt	*3.64*	15	−41.70	(2222)
$C_{11}H_{18}O_3S_2$	Camphorylmethyl β-disulfoxide ($C_{10}H_{15}O.SO.SO.CH_3$)	$CHCl_3$	2.5	16.5	44.48*	(907)
		HCl.EtOH	1.0	22	29.50*	
$C_{12}H_{18}O_2S$	Camphor-β-thiol acetate	EtOH	5	8	−41	(1301)
$C_{14}H_{24}O_3S_2$	Camphoryl-*n*-butyl β-disulfoxide	$CHCl_3$	1.0	17	−23.60	(907)
$C_{16}H_{20}O_2S$	Camphor-β-thiol benzoate	Me_2CO	3.22	13	−16.4	(1301)
$C_{20}H_{30}O_4S_2$	Dicamphoryl α, β-disulfoxide ($[SO.C_{10}H_{15}O]_2$)	$CHCl_3$	5.0	16.5	−64.68*	(907)
		$CHCl_3$	1.0	16.5	−68.80	
		EtOH	1.0	16.5	−65.20	
		HCl.EtOH	1.0	17.5	−52.40*	
		AcOH	1.0	20	−58.60	
$C_{20}H_{30}O_6S_2$	*d*-Camphoryl-α-disulfone ($[SO_2.C_{10}H_{15}O]_2$)	$CHCl_3$	2.03	22	30.6	(1968)
$C_{20}H_{30}O_6S_3$	Camphor-β-sulfonic thioanhydride ($S(SO_2.C_{10}H_{15}O)_2$)	$CHCl_3$	2.5	19	−31.68	(909)
$C_{20}H_{30}O_6S_4$	Dicamphor-β-sulfonyl disulfide ($S[SO_2.C_{10}H_{15}O_2]$)	$CHCl_3$	2.5	19	−108.56	(909)
$C_{48}H_{58}Cl_6O_6PtS_2$	Camphoryldianisylsulfonium chloroplatinate† (in epichlorohydrin)		2.009	22	−51.8	(1968)
$C_{52}H_{66}Cl_6O_6PtS_2$	Camphoryldiphenethylsulfonium chloroplatinate (in epichlorohydrin)		2.02	28	−57.3	
Sulfur derivatives of camphor: β-Sulfonic derivatives of camphor, methylcamphor, α-chlorocamphor, α-bromocamphor and α, α′-dibromocamphor						
$C_{10}H_{13}Br_2NO_2S$	α, α′-Dibromocamphor-β-sulfonanhydramide	Me_2CO	5	11	−7.2	(40)
$C_{10}H_{14}BrClO_3S$	α-Bromocamphor-β-sulfonyl chloride	$CHCl_3$	10	5	104	(40)
$C_{10}H_{14}BrNO_2S$	α-Bromocamphor-β-sulfonanhydramide	EtOH	*2.51*		134	(1302.5)
		Me_2CO	5	20	99.3	(40)
	α′-Bromocamphorsulfonanhydramide	Me_2CO	5	14	40.5	
$C_{10}H_{24}Br_2O_3S$	α-Bromocamphor-β-sulfonic bromide	$CHCl_3$	4	12	119	(40)
$C_{10}H_{14}ClNO_2S$	α-Chlorocamphor-β-sulfonanhydramide	EtOH	1.28		39.0	(1302.5)
		Me_2CO	5	11	59.5	(40)
$C_{10}H_{14}Cl_2O_3S$	α-Chlorocamphor-β-sulfonic chloride	$CHCl_3$	5	11	80.8	(40)
$C_{10}H_{15}BrO_3S$	Camphor-β-sulfonic bromide	$CHCl_3$	10	18	26.0	(40)
$C_{10}H_{15}BrO_4S$	α-Bromo-β-camphorsulfonic acid, potassium salt	H_2O	26.56		72.1	(1302.5)
	Sodium salt	H_2O	3.422	14	12.22	(1390)
$C_{10}H_{15}ClO_3S$	Camphor-β-sulfonic chloride	$CHCl_3$	10	18	31.1	(40); *cf.* (1080)
		$CHCl_3$	5	20	32.01	(910)
$C_{10}H_{15}ClO_4S$	α-Chlorocamphor-β-sulfonic acid	H_2O	*17.92*		49.6	(1302.5)
	Barium salt ($5.5H_2O$)	H_2O	2.081	10	46.8	(1080)
	Sodium salt	H_2O	2.01	10	64	(1080)
$C_{10}H_{15}NO_2S$	Camphor-β-sulfonanhydramide	EtOH	0.46		−45.0	(1302.5)
$C_{10}H_{16}BrNO_3S$	α-Bromocamphor-β-sulfonamide	EtOH	*2.0*		89.0	(1302.5)
		Me_2CO	5	17	106	(40)
$C_{10}H_{16}ClNO_3S$	α-Chlorocamphor-β-sulfonamide	EtOH	3.05		75.0	(1302.5)
		Me_2CO	5	15	83.2	(40)
$C_{10}H_{16}O_4S$	Camphor-β-sulfonic acid	$CHCl_3$	5.0	20	39.47	(910)
		H_2O	5.0	20	23.95	
	Ammonium salt	H_2O			20.1	(268)
$C_{10}H_{17}NO_3S$	Camphor-β-sulfonamide	EtOH	4.3		23.0	(1302.5)
		$CHCl_3$	10	17	1.5	(40)

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* Mutarotation.

† $[(CH_3.O.C_6H_4)_2S.C_{10}H_{15}O]_2PtCl_6$.

Sulfur derivatives of camphor: β-Sulfonic derivatives of camphor, methylcamphor, α-chlorocamphor, α-bromocamphor and α, α′-dibromocamphor.—(Continued)

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_{11}H_{17}ClO_3S$	α-Methylcamphor-β-sulfonyl chloride	C_6H_6	5	20	29.5	(723)
$C_{11}H_{18}O_4S$	Methylcamphor β-sulfonate ($CH_3.O.SO_2.C_{10}H_{16}O$)	$CHCl_3$	*5.0*	23	43.61	(408)
		$CHCl_3$	*2.5*	23	43.4	
$C_{11}H_{18}O_4S$	α-Methylcamphor-β-sulfonic acid	H_2O	5.04	20	18.7	(723)
$C_{11}H_{19}NO_3S$	α-Methylcamphor-β-sulfonamide	$CHCl_3$	2.5	20	−6.3	(723)
$C_{12}H_{20}O_4S$	Ethyl camphor-β-sulfonate	$CHCl_3$	*5.0*	23	43.91	(408)
		$CHCl_3$	*2.5*	23	43.28	
$C_{15}H_{24}BrNO_3S$	α-Bromocamphorsulfonpiperidide	$CHCl_3$	3	13	111	(40)
$C_{15}H_{25}NO_3S$	Camphor-β-sulfonpiperidide					
	M. P. 140° isomer (a)	$CHCl_3$	5	15	32.2	(40)
	M. P. 56° isomer (b)	$CHCl_3$	10	10	33.6	
$C_{16}H_{19}BrClNO_3S$	α-Chlorocamphor-β-sulfon-p-bromoanilide	H_2O	*6.55*		73.6	(1302.5)
$C_{16}H_{19}Br_2NO_3S$	α-Bromocamphor-β-sulfon-p-bromoanilide	EtOH	*15.53*		209.0	(1302.5)
$C_{16}H_{20}BrNO_3S$	α-Bromocamphorsulfonanilide	$CHCl_3$	4.2	7	177	(40)
$C_{16}H_{20}BrNO_3S$	Camphor-β-sulphon-p-bromoanilide	EtOH	1.35		21.4	(1302.5)
$C_{16}H_{20}O_4S$	Phenol camphor-β-sulfonate	$CHCl_3$	2.5	22	40.56	(909); *cf.* (408)
$C_{16}H_{21}NO_3S$	Camphor-β-sulfonanilide	EtOH	*7.44*		27.4	(1302.5)
$C_{16}H_{21}NO_3S$	Camphorsulphonanilide	$CHCl_3$	10	17	67.3	(40)
$C_{17}H_{20}O_5S$	o-Aldehydophenyl camphor-β-sulfonate	$CHCl_3$	*2.5*	23	39.6	(408)
$C_{17}H_{22}O_4S$	o-Tolyl camphor-β-sulfonate	$CHCl_3$	2.5	21	46.0	(904); *cf.* (408)
		$CHCl_3$	5.0	21	45.8	
$C_{17}H_{23}NO_3S$	Camphor-β-sulfonyl-p-toluidide	$CHCl_3$	2.5	21	71.2	(904)
		$CHCl_3$	5.0	21	68.3	(604)
$C_{18}H_{23}NO_4S$	Camphor-β-sulfonyl-p-acetylanilide	$CHCl_3$	2.5	23	67.0	(904)
		$CHCl_3$	5.0	23	67.2	
$C_{18}H_{25}NO_3S$	Camphor-β-sulfonyl-p-ethylphenylamide	$CHCl_3$	2.5	21	63.8	(904)
		$CHCl_3$	5.0	21	63.6	
$C_{20}H_{22}O_4S$	α-Naphthyl camphor-β-sulfonate	$CHCl_3$	*2.5*	23	38.24	(408)
	β-Naphthyl camphor-β-sulfonate	$CHCl_3$	*2.5*	23	30.16	
$C_{20}H_{26}O_6S$	Eugenyl camphor-β-sulfonate	$CHCl_3$	2.5	21	28.4	(904)
		$CHCl_3$	5.0	21	27.8	
	Isoeugenyl camphor-β-sulfonate	$CHCl_3$	2.5	21	26.4	
		$CHCl_3$	5.0	21	27.6	
$C_{22}H_{24}O_5S$	2-Aceto-α-naphthyl camphor-β-sulfonate	$CHCl_3$	*2.5*	23	50.02	(408)
$C_{23}H_{25}NO_4S$	Camphor-β-sulfonyl-p-benzoylanilide	$CHCl_3$	2.5	21	55.6	(904)
		$CHCl_3$	5.0	21	57.1	
$C_{25}H_{26}O_5S$	α, β-Benzoylvinylphenyl camphor-β-sulfonate, $C_6H_5.CO.CH:CH.C_6H_4.O.SO_2.C_{10}H_{15}O$	$CHCl_3$	*2.5*	23	27.2	(408)
$C_{26}H_{34}O_8S_2$	Pyrocatechol dicamphor-β-sulfonate	$CHCl_3$	2.5	22	42.72	(909)
$C_{26}H_{34}O_8S_2$	Resorcinol dicamphor-β-sulfonate	$CHCl_3$	2.5	22	42.48	(909)
$C_{26}H_{34}O_8S_2$	Hydroquinone dicamphor-β-sulfonate	$CHCl_3$	2.5	22	50.00	(909)
$C_{26}H_{48}O_4S$	Cetyl camphor-β-sulfonate	$CHCl_3$	2.5	20	21.74	(910)
$C_{36}H_{48}O_{12}S_3$	Pyrogallol tricamphor-β-sulfonate	$CHCl_3$	2.5	22	27.60	(909)
$C_{36}H_{48}O_{12}S_3$	Phloroglucinol tricamphor-β-sulfonate	$CHCl_3$	2.5	22	57.64	(909)
$C_{40}H_{76}O_4S$	Myricyl camphor-β-sulfonate	$CHCl_3$	2.5	20	15.30	(910)

Sulfur derivatives of camphor: π-Sulfonic derivatives of camphor, α-chlorocamphor and α-bromocamphor

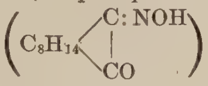
$C_{10}H_{14}BrClO_3S$	α-Bromocamphor-π-sulfonyl chloride	$CHCl_3$	5.486	14	131	(1080)
$C_{10}H_{14}BrO_4SNH_4$	Ammonium d-bromocamphor-π-sulfonate	H_2O	1.81		84.4	(1667)
	Ammonium l-bromocamphor-π-sulfonate	H_2O	1.81		−84.2	
$C_{10}H_{14}BrO_4SNH_4$	Ammonium α-bromo-π-camphorsulfonate	H_2O	*18.57*		75.1	(1302.5)
$C_{10}H_{14}Cl_2O_3S$	α-Chlorocamphor-π-sulfonyl chloride	$CHCl_3$	4	7	110.5	(1080)
$C_{10}H_{15}O_4SNH_4$	Ammonium d-camphor-π-sulphonate	EtOH	0.5001		80.5	(1676)
		H_2O	2.499		68.0	
		H_2O	1.515		66.3	
		H_2O	0.53		68.9	
	Ammonium l-camphor-π-sulfonate	EtOH	0.537		−80.1	(1676)
		H_2O	2.50		−68.3	
		H_2O	1.51		−67.9	
		H_2O	0.51		−68.6	

Sulfur derivatives of camphor: π-Sulfonic derivatives of camphor, α-chlorocamphor and α-bromocamphor.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{16}BrNO_3S$	α-Bromocamphor-π-sulfonamide	EtOH	4.595	11	112.4	(1080)
		EtOH	11.61		67.2	(1302.5)
$C_{10}H_{16}ClNO_3S$	α-Chlorocamphor-π-sulfonamide	EtOH	5.066	11	90.16	(1080)
$C_{31}H_{37}N_2O_6S$	Strychnine α-camphor-π-sulfonate	EtOH	0.5237		23.9	(1676)
		$CHCl_3$	0.5318		22.6	
		H_2O	0.5321		11.3	
	Strychnine *l*-camphor-π-sulfonate	EtOH	0.5166		−48.4	
		$CHCl_3$	0.5442		−63.4	
		H_2O	0.5017		−50.8	

α-DIKETONES AND DERIVATIVES

Camphorquinone oximes, including isonitrosocamphor

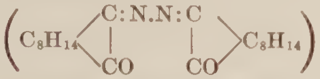
Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{14}N_2O_2$	Camphorquinone dioxime peroxide	EtOH	2.00	20	18.7	(585)
$C_{10}H_{15}NO_2$	Isonitrosocamphor (camphorquinone monoxime)  $\left(C_8H_{14}\begin{matrix}\diagup C:NOH \\ \mid \\ \diagdown CO\end{matrix}\right)$	C_6H_6	0.81		195	(278)
	(stable M. P. 152°)	$CHCl_3$	1.0		197.0	(589)
	(stable M. P. 152°)	2% NaOH	1.0		288.0	
	(unstable M. P. 114°)	$CHCl_3$	1.0		172.9	
	(unstable M. P. 114°)	2% NaOH	1.0		275.3	
$C_{10}H_{15}N_3O_3$	Pernitrosocamphorquinoneoxime	$CHCl_3$	0.566		103.1	(612)
$C_{10}H_{16}N_2O_2$	Camphorquinone-α-dioxime	$CHCl_3$	1.0		−51.7	(589); *cf.* (608)
		2% NaOH	1.0		−103.8	
	Camphorquinone-β-dioxime	2% NaOH	1.0		−24.5	
	Camphorquinone-γ-dioxime	$CHCl_3$	1.0		16.4	
		2% NaOH	1.0		14.3	
	Camphorquinone-δ-dioxime	$CHCl_3$	1.0		52.8	
		2% NaOH	1.0		87.0	
	Camphorquinone-α-dioxime	EtOH	1.57	20	−63.6	(585)
		2% NaOH	2.58	20	−98.3	
	Camphorquinone-β-dioxime	2% NaOH	1.87	20	−24.1	
	Camphorquinone-γ-dioxime	EtOH	1.00	20	22.4	
		2% NaOH	18.1		12.6	
	Camphorquinone-δ-dioxime	2% NaOH	1.85		83.6	
		EtOH	1.02	21	75.5	
$C_{10}H_{16}N_4O$	Camphorylazoimideoxime	C_6H_6	2.01		−198.2	(594)
		EtOH	2.01		−160.1	
		Me_2CO	2.05		−163.7	
		$CHCl_3$	2.09		−161.3	
$C_{11}H_{17}NO_2$	Isonitrosocamphor *O*-methyl ether	$CHCl_3$	2.01		197.7	(586)
	Isonitrosocamphor *N*-methyl ether	$CHCl_3$	4.55		279.8	(586)
$C_{12}H_{19}NO_2$	Isonitrosocamphor *N*-ethyl ether	$CHCl_3$	1.246		248.1	(599)
$C_{17}H_{19}N_3O_4$	Benzoylpernitrosocamphorquinoneoxime	$CHCl_3$	0.596		84.7	(612)

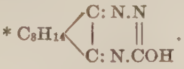
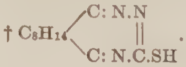
Camphorquinone hydrazones

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{16}N_2O$	Camphorquinone α-hydrazone	$CHCl_3$	1.244		287.4	(614)
	Camphorquinone β-hydrazone	$CHCl_3$	1.253		231.3	
$C_{11}H_{16}N_2O_2$	Formylcamphorquinone α-hydrazone	$CHCl_3$	0.688		258.0	(614)
$C_{12}H_{18}N_2O_2$	Acetylcamphorquinone α-hydrazone	$CHCl_3$	1.113		265.5	(614)
		10% NaOH	0.833		252.0	
	Acetylcamphorquinone β-hydrazone	$CHCl_3$	1.556		223.8	
$C_{16}H_{19}BrN_4O_2$	Pernitrosocamphorquinone *p*-bromophenylhydrazone	$CHCl_3$	1.176		301.0	(612)
	Isomeride	$CHCl_3$	0.934		235.5*	
$C_{16}H_{20}N_2O$	Camphorquinone phenylhydrazone	EtOH	*1*		438	(1172)
		AcOEt	*1*		380*	
$C_{16}H_{20}N_2O$	Camphorquinone α-phenylhydrazone	EtOH	1.0		398*	(615)
		Py	1.0		435.5	
		$PhNO_2$	1.0		453.9	
$C_{16}H_{20}N_2O$	Camphorquinone β-phenylhydrazone	EtOH	1.0		397*	(615)
		Py	1.0		395.5	
		C_6H_6	1.0		369.5	
		$PhNO_2$	1.0		420.5	

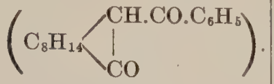
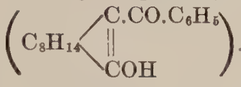
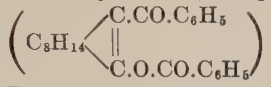
* Mutarotation.

Camphorquinone hydrazones.—(Continued)

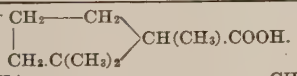
Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{16}H_{20}N_4O_2$	Pernitrosocamphorquinone phenylhydrazone.	$CHCl_3$	0.498		374.4	(612)
$C_{16}H_{21}N_3O$	Camphorquinone phenylhydrazoneoxime....	$CHCl_3$	0.883		147	(611)
$C_{17}H_{20}N_2O$	Benzylidenecamphorquinone α-hydrazone...	$CHCl_3$	1.517		159.2	(614)
$C_{17}H_{20}N_2O_2$	α-Benzoylcamphorquinone α-hydrazone.....	$CHCl_3$	0.427		204.9	(614)
$C_{20}H_{28}N_2$	Dicamphenepyrazine......................	$CHCl_3$	1.020		55.5	(608)
$C_{20}H_{28}N_2O_2$	Azocamphanone...........................	$CHCl_3$	0.260	30	188	(1955)
	 $\left(C_8H_{14}\left\langle\begin{matrix}C:N.N:C\\ \vert\qquad\qquad\vert\\ CO\qquad CO\end{matrix}\right\rangle C_8H_{14}\right)$	MeOH	0.166	30	229	
		$CHCl_3$	1.242		174.5	(614)
$C_{20}H_{30}N_2$	Dihydrodicamphenepyrazine...............	$CHCl_3$	1.047		−283.3	(608)
$C_{20}H_{30}N_2$	Epidihydrodicamphenepyrazine............	$CHCl_3$	1.042		425.5	(608)
$C_{22}H_{24}N_2O$	Camphorquinone diphenylhydrazone.......	C_6H_6	0.513		126.6	(44)
$C_{23}H_{26}N_2O$	Camphorquinone benzylphenylhydrazone...	C_6H_6	*0.49*		636	(44)
	Cyclic derivatives of camphorquinone					
$C_{11}H_{15}N_3O$	Camphanehydroxytriazine*................	$CHCl_3$	1.142		22.6	(614)
$C_{11}H_{15}N_3S$	Camphanethiotriazine†...................	$CHCl_3$	1.0		−73.3	(615)
$C_{13}H_{17}N_3O_2$	Acetylcamphanehydroxytriazine...........	$CHCl_3$	1.222		42.2	(614)
$C_{16}H_{18}N_2$	Camphanoquinoxaline.....................	EtOH	2.497	23.0	31.4‡	(1952)
		$CHCl_3$	1.999	27.0	29.26‡	
		MeOH	2.138	30.0	33.45	
$C_{16}H_{20}BrN_3O$	Camphoryl-*p*-bromophenyltriazene.........	$CHCl_3$	0.915		62.7	(595)
$C_{16}H_{20}N_2$	Camphoranodihydroquinoxaline............	$CHCl_3$	1.144	20	−180.0‡	(1952)
$C_{16}H_{20}N_4O_3$	Camphoryl-*o*-nitrophenyltriazene..........	$CHCl_3$	0.425		−242.8	(595)
	Camphoryl-*m*-nitrophenyltriazene..........	$CHCl_3$	0.5		0	
	Camphoryl-*p*-nitrophenyltriazene..........	$CHCl_3$	0.435		114.8	
$C_{16}H_{21}N_3O$	Camphorylphenyltriazene§................	$CHCl_3$	1.57		18.6	(595)
$C_{17}H_{22}BrN_3O$	Camphoryl-*p*-bromophenylmethyltriazene (needles)............................	$CHCl_3$	0.90		−218.0	(595)
	Camphoryl-*p*-bromophenylmethyltriazene (prisms).............................	$CHCl_3$	0.90		−232.1	
$C_{17}H_{22}N_4O_3$	Camphoryl-*o*-nitrophenylmethyltriazene.....	$CHCl_3$	0.94		301.0	(595)
	Camphoryl-*m*-nitrophenylmethyltriazene....	$CHCl_3$	0.495		181.6	
	Camphoryl-*p*-nitrophenylmethyltriazene...	$CHCl_3$	1.18		310.8	
$C_{17}H_{23}N_3O$	Camphorylphenylmethyltriazene...........	$CHCl_3$	1.08		235.2	(595)
$C_{17}H_{23}N_3O_2$	Camphoryl-*p*-methoxyphenyltriazene.......	$CHCl_3$	0.84		49.0	(595)
$C_{18}H_{19}N_3O_2$	Benzoylcamphanehydroxytriazine..........	$CHCl_3$	1.123		7.7	(614)
	Camphorquinone semicarbazones					
$C_{11}H_{17}N_3O_2$	Camphorquinone α-semicarbazone..........	MeOH	1.576		277.6	(614)
		very dil. KOH	1.337		333.3	
	Camphorquinone β-semicarbazone..........	MeOH	1.576		200.9	
$C_{11}H_{17}N_3OS$	Camphorquinone α-thiosemicarbazone......	$CHCl_3$	1.0		314.4	(615)
$C_{17}H_{21}N_2OS$	Camphorquinone phenylthiocarbamylhydrazone................................	$CHCl_3$	*1.0*		259.4	(615)
$C_{17}H_{21}N_3O_2$	Camphorquinone α-phenylcarbamylhydrazone..............................	$CHCl_3$	0.883		229.3	(614)
	Camphorquinone β-phenylcarbamylhydrazone..............................	$CHCl_3$	0.851		191.9	
	β-DIKETONES AND ENOLIC ISOMERIDES					
$C_{17}H_{18}BrNO_4$	α′-*m*-Nitrobenzoyl-α-bromocamphor........	$CHCl_3$	1.56	21	87.9	(606)
	α-*m*-Nitrobenzoyl-α′-bromocamphor........	$CHCl_3$	1.85	21	−26.1	
$C_{17}H_{18}ClNO_4$	α′-*m*-Nitrobenzoyl-α-chlorocamphor........	$CHCl_3$	2.24	20	40 4	(606)
	α-*m*-Nitrobenzoyl-α′-chlorocamphor........	$CHCl_3$	1.75	21	7.1	
$C_{17}H_{18}N_2O_6$	α′-*m*-Nitrobenzoyl-α-nitrocamphor..........	$CHCl_3$	2.00	20	175.6	(601)
	α-*m*-Nitrobenzoyl-α′-nitrocamphor..........	$CHCl_3$	2.00	20	178.1	
$C_{17}H_{19}BrO_2$	α′-Benzoyl-α-bromocamphor...............	C_6H_6	2.0	21	−10.0	(605)
		$CHCl_3$	2.01	21	10.3	
	α-Benzoyl-α′-bromocamphor...............	C_6H_6	2.00	21	−53.2	
		$CHCl_3$	2.58	21	−19.3	
$C_{17}H_{19}ClO_2$	α′-Benzoyl-α-chlorocamphor...............	$CHCl_3$	1.67	21	−27.9	(605)
	α-Benzoyl-α′-chlorocamphor...............	$CHCl_3$	1.59	21	26.2	
$C_{17}H_{19}IO_2$	Benzoyliodocamphor......................	$CHCl_3$	2.05	21	47.7	(601)

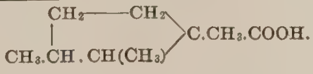
*  $C_8H_{14}\left\langle\begin{matrix}C:N.N\\ \vert\qquad\Vert\\ C:N.COH\end{matrix}\right.$. †  $C_8H_{14}\left\langle\begin{matrix}C:N.N\\ \qquad\Vert\\ C:N.C.SH\end{matrix}\right.$. ‡ Mutarotation. § $C_{10}H_{15}O.N:N.NH.C_6H_5$.

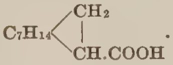
β-Diketones and Enolic Isomerides.—(*Continued*)

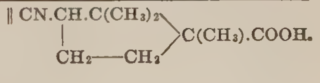
Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{17}H_{19}NO_4$	*m*-Nitrobenzoylcamphor (enolic)	$CHCl_3$	1.96	20	209.5	(606)
	o-Nitrobenzoylcamphor (enolic)	$CHCl_3$	1.86	21	60.5*	
$C_{17}H_{19}NO_4$	α′, α-Benzoylnitrocamphor	$CHCl_3$	2.00	25	163.0	(601)
	α, α′-Benzoylnitrocamphor	$CHCl_3$	2.00	20	245.2	
$C_{17}H_{20}O_2$	α-Benzoylcamphor  $\left(C_8H_{14}\Big\langle\begin{matrix}CH.CO.C_6H_5\\ \vert\\ CO\end{matrix}\right).$	EtOH	1.00	21	137.5	(580)
		$CHCl_3$	2.00	21	125.0	
$C_{17}H_{20}O_2$	α-Hydroxy-β-benzoylcamphene (enolic isomeride)  $\left(C_8H_{14}\Big\langle\begin{matrix}C.CO.C_6H_5\\ \Vert\\ COH\end{matrix}\right)$	$CHCl_3$	2.05	21	216*	(580)
		EtOH	1.17	21	208*	
$C_{24}H_{24}O_3$	α-Benzoxy-β-benzoylcamphene  $\left(C_8H_{14}\Big\langle\begin{matrix}C.CO.C_6H_5\\ \Vert\\ C.O.CO.C_6H_5\end{matrix}\right)$	$CHCl_3$	4.01	22	189.7	(580)
		EtOH	1.01	27	187.3	
$C_{24}H_{26}O_2$	Enolic benzoylcamphor benzyl ether	$CHCl_3$	2.32	21	155.8	(584)
	CARBOXYLIC ACIDS					
	Monocarboxylic Acids					
	Fencholic and campholic acids and derivatives					
$C_{10}H_{17}ClO$	Fencholyl chloride ($(CH_3)_2C.C_6H_{10}.COCl$)		1.0045^{20}	19	−2.43	(2122)
$C_{10}H_{18}O_2$	Campholic acid ($CH_3.C_8H_{14}.COOH$)	C_6H_6		20	59.26	(1818) 1832)
$C_{10}H_{19}NO_2$	α-Aminocampholic acid	H_2O	2.07	26	67	(1528)
	β-Aminocampholic acid	H_2O	2.5	25	16.4	
$C_{10}H_{20}ClNO_2$	α-Aminocampholic hydrochloride	H_2O	5.0	24	44.7	(1528)
	β-Aminocampholic hydrochloride	H_2O	5.0	26	41.3	
$C_{11}H_{18}N_2O$	Cyanocampholic amide ($CN.CH_2.C_8H_{14}.CO.NH_2$)	EtOH	1.05	16	85.63	(1553)
$C_{12}H_{22}O_2$	Dimethylcampholic acid ($(CH_3)_2.CH.C_8H_{14}.COOH$)	EtOH			47.4	(805)
$C_{12}H_{22}O_2$	Ethyl campholate ($CH_3.C_8H_{14}.COOC_2H_5$)			20	40.49	(1818) (1832)
$C_{12}H_{23}NO$	Dimethylcampholamide	EtOH			70.8	(805)
$C_{13}H_{24}O_2$	Methylethylcampholic acid	EtOH	2.41	15	55.40	(1281)
$C_{14}H_{26}O_2$	Diethylcampholic acid	EtOH	3.45	15	60.87	(1281)
$C_{14}H_{27}NO$	Diethylcampholamide	EtOH	2.68	18	77.08	(1281)
$C_{16}H_{27}NO$	Diallylcampholamide	EtOH	8.48	18	40.50	(1281)
$C_{17}H_{23}BrO_2$	Phenylbromohomocampholic acid ($C_6H_5.CHBr.CH_2.C_8H_{14}.COOH$)	PhMe			44.8	(820)
$C_{17}H_{23}BrO_3$	*p*-Bromophenylhydroxyhomocampholic acid ($BrC_6H_4.CHOH.CH_2.C_8H_{14}.COOH$)	PhMe			57.05	(820)
$C_{18}H_{23}NO_2$	*o*-Tolyl cyanocampholate ($CN.CH_2.C_8H_{14}.COOC_6H_4.CH_3$)	EtOH	8.95	12	21.6	(1553)
	m-Tolyl cyanocampholate	C_6H_6	10.5	21	26.1	
		EtOH	9.9		26.2	
	p-Tolyl cyanocampholate	C_6H_6	5.7	20	17.5	
$C_{24}H_{31}NO$	Dibenzylcampholamide ($(C_6H_5.CH_2)_2CH.C_8H_{14}.CO.NH_2$)	EtOH	2.72	19	33.12	(1281)
		EtOH	2.52	19	34.30	
	Other monocarboxylic acids					
$C_9H_{17}O_2$	Dihydrolauronolic acid†		0.9008	25.5	1.74	(1516)
$C_9H_{16}O_2$	Teresantalic acid‡	EtOH	*25*	18	−70.40	(1925)
$C_{10}H_{18}O_2$	Dihydrofencholenic acid§		0.9816^{15}_{15}	15.5	4.3	(1359)
$C_{10}H_{15}NO_2$	Cyanodihydrocampholytic acid‖	EtOH	6.0	22	25.3	(1528)
$C_{10}H_{15}NO_2$	Cyanocamphoranic acid¶	EtOH	10	26	67.3	
$C_{11}H_{16}O_2$	Bornylene-2-carboxylic acid**	AcOEt	3.30		−95.7	(238)
$C_{11}H_{17}N$	Camphanecarboxylic acid nitrile	MeOH	12.3		1	(613)

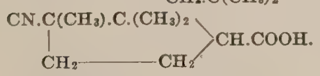
* Mutarotation.

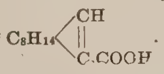
†  $\begin{matrix}CH_2\text{——}CH_2\\ \vert\\ CH_2.C(CH_3)_2\end{matrix}\Big\rangle CH(CH_3).COOH.$

‡  $\begin{matrix}CH_2\text{——}CH_2\\ \vert\\ CH_3.CH.CH(CH_3)\end{matrix}\Big\rangle C.CH_2.COOH.$

§  $C_7H_{14}\Big\langle\begin{matrix}CH_2\\ \vert\\ CH.COOH\end{matrix}.$

‖  $\begin{matrix}CN.CH.C(CH_3)_2\\ \vert\\ CH_2\text{——}CH_2\end{matrix}\Big\rangle C(CH_3).COOH.$

¶  $\begin{matrix}CN.C(CH_3).C.(CH_3)_2\\ \vert\\ CH_2\text{————}CH_2\end{matrix}\Big\rangle CH.COOH.$

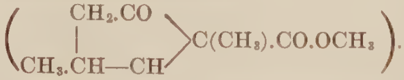
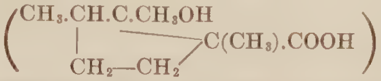
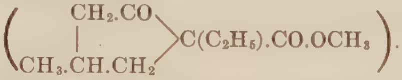
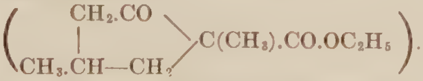
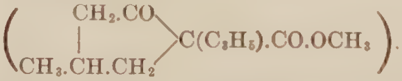
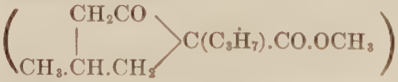
**  $C_8H_{14}\Big\langle\begin{matrix}CH\\ \Vert\\ C.COOH\end{matrix}.$

Other monocarboxylic acids.—(Continued)

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_{11}H_{18}O_2$	*l*-Camphane-2-carboxylic acid*	AcOEt	3.74	19	−37.8	(237); *cf.* (238)
$C_{12}H_{18}O_2$	Methyl bornylene-2-carboxylate	AcOEt	7.17		−93.6	(238)
		AcOEt	2.88	19	−98.8	(237)
$C_{12}H_{20}O_2$	1, 2, 2, 3-Tetramethylcyclopentane-1-acrylic acid†	C_6H_6		20	66.82	(1835)
$C_{13}H_{20}O_2$	Methyl 2, 2-dimethyl-norcamphane-3-spirocyclopropanecarboxylate‡		1.0268	18.5	6.79	(257)
$C_{14}H_{24}O_2$	Ethyl 1, 2, 2, 3-tetramethylcyclopentane-1-acrylate			20	57.51	(1835)
		C_6H_6		2	57.11	

KETONIC ACIDS

Derivatives of cyclopentanone and cyclopentanol

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_9H_{14}O_3$	Methyl 1-4-dimethyl-2-cyclopentanonecarboxylate 		1.053	15	78.58	(811)
$C_9H_{16}O_3$	*d-cis*-2-Hydroxy-1, 2, 3-trimethylcyclopentane-1-carboxylic acid 	EtOH	5.69	23	35.7	(1956)
$C_{10}H_{16}O_3$	Methyl 4-methyl-1-ethyl-2-cyclopentanonecarboxylate 		1.041	15	59.14	(811)
$C_{10}H_{16}O_3$	Ethyl 1, 4-dimethyl-2-cyclopentanonecarboxylate 		1.01	15	70.00	(811)
$C_{11}H_{16}O_3$	Methyl 4-methyl-1-allyl-2-cyclopentanonecarboxylate 		1.029	15	58.18	(811)
$C_{11}H_{18}O_3$	Methyl 4-methyl-1-propyl-2-cyclopentanonecarboxylate 		1.02	15	53.3	(811)
$C_{11}H_{18}O_3$	Ethyl 4-methyl-1-ethyl-2-cyclopentanonecarboxylate		1.01	15	51.7	(811)
$C_{11}H_{18}O_3$	Propyl 1, 4-dimethyl-2-cyclopentanonecarboxylate		0.991	15	50.28	(811)
$C_{12}H_{18}O_3$	Ethyl 4-methyl-1-allyl-2-cyclopentanonecarboxylate		1.01	15	62.16	(811)
$C_{12}H_{20}O_3$	Ethyl 4-methyl-1-propyl-2-cyclopentanonecarboxylate		1.00	15	51.8	(811)
$C_{13}H_{22}O_3$	Ethyl 4-methyl-1-isobutyl-2-cyclopentanonecarboxylate		0.994	15	30.33	(811)

Camphorcarboxylic acid and isomers, homologues and derivatives

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_{10}H_{16}O_3$	α-Thujaketonic acid	Et_2O	*6.945*		194.0	(2022); *cf.* (2114)
		AcOH	*4.6163*		224.1	
		$CHCl_3$	*5.132*		244.8	
		H_2O	*0.6754*		244.0	
		MeOH	*5.5649*		214.8	
	Ammonium salt	H_2O	*0.881*	19	170	(2022)

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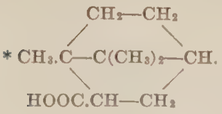
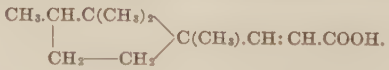
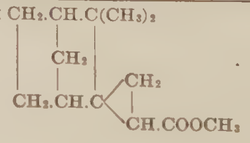
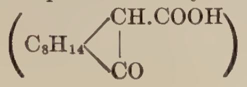
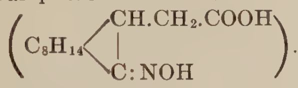
* 

† 

‡ 

Camphorcarboxylic acid and isomers, homologues and derivatives.—(Continued)

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_{10}H_{17}NO_3$	α-Thujaketonic acid oxime (alk. prep.)	MeOH	*3.933*		−5.0	(2022)
	(neutral prep.)	AcOH	*1.7008*		5.56	
		MeOH	*4.473*		very small	
$C_{11}H_{16}O_3$	*l*-Epicamphorcarboxylic acid	AcOEt	3.89	19	−18.5	(237)
$C_{11}H_{16}O_3$	*d*-Camphor-α-carboxylic acid	C_6H_6	1.52		18	(822)
		EtOH	1.52		60	
		MeCN	1.52		62.5	
		EtI	1.52		73.3	
		H_2O	1.52		73.3	
		NaOH	1.52		87.5	
		H_2O	1.52			
		EtOH	1	18	61.9	(440)
	l-Camphorcarboxylic acid	EtOH	1	18	−61.9	(440)
$C_{11}H_{17}NO_2$	Camphorcarboxamide (λ = 5461)	EtOH			100	(724)
		C_6H_6			75*	
$C_{11}H_{19}N_3O_3$	α-Thujaketonic semicarbazone	AcOH	*2.29*	16	227.8	(2022)
$C_{12}H_{18}O_3$	Camphoracetic acid ($C_{10}H_{15}O.CH_2.COOH$)	EtOH	2.30	14	72.6	(1553)
		EtOH			70.7	(797)
$C_{12}H_{18}O_3$	Methyl camphorcarboxylate				161.22*	(724); *cf.* (1288)
$C_{12}H_{19}NO_3$	Camphoroximeacetic acid 	EtOH	3.38	21	−5.9	(598)
$C_{13}H_{18}BrNO_3$	Acetyl α, α′-bromocamphorcarboxamide	C_6H_6	2		−0.5*	(724)
$C_{13}H_{20}O_2$	Camphor-β-propionic acid ($C_{10}H_{15}O.CH_2.CH_2.COOH$)	EtOH			45.6	(797)
$C_{13}H_{20}O_3$	α-Methyl methylcamphorcarboxylate	EtOH			17.25	(1432)
	β-Methyl methylcamphorcarboxylate	EtOH			75	
$C_{14}H_{22}O_3$	α-Methyl ethylcamphorcarboxylate	EtOH			58	(1432)
	β-Methyl ethylcamphorcarboxylate	EtOH			87.8	
$C_{14}H_{22}O_5$	1-Methyl acid campholethanoyl-1-methanoate†	EtOH	2.7	20	49.37	(1553)
$C_{15}H_{22}O_5$	Dimethyl carboxycamphoracetate	EtOH			65.70	(797)
$C_{15}H_{24}O_3$	Methyl *l*-α-propylcamphor-α-carboxylate (isomeride a)	EtOH			52.57	(793)
	(isomeride b)	EtOH			49.73	
$C_{16}H_{25}NO_2$	Camphorcarboxypiperidide ($C_{10}H_{15}O.CO.N.C_5H_{10}$)	C_6H_6			24.9‡	(724)
		EtOH			111‡	
$C_{17}H_{26}O_5$	Diethyl-1-ethanoatecamphomethanoate§	EtOH	11.89	12.5	59.7	(1553)
$C_{18}H_{22}O_3$	Benzyl camphorcarboxylate ($C_{10}H_{15}O.CO.O.CH_2.C_6H_5$)	EtOH	1.66	15	58.23	(1553)
$C_{20}H_{24}O_5$	Phenylmethyl ethanoatecamphomethanoate‖	EtOH	3.2	16	41.6	(1553)
$C_{21}H_{26}O_5$	1-Methyl 1-benzylethanoatecamphomethanoate¶	EtOH	9.03	22	46.0	(1553)
	Other ketonic acids, including their nitriles and derivatives of enol forms					
$C_{10}H_{14}O_3$	*d*-Camphenonic acid**	EtOH	*8.0*	20	79.1	(62)
$C_{10}H_{15}NO_2$	*l*-Camphenonic amide	EtOH	*2.8*	20	−58.3	(62)
$C_{11}H_{16}BrNO$	Cyanodihydrocarvone hydrobromide	EtOH	1.415	14	25.5	(328)
		EtOH	1.289	14	25.8	
$C_{11}H_{16}ClNO$	Cyanodihydrocarvonehydrochloride	EtOH	3.208	18	25.6	(328)
$C_{11}H_{17}NO_2$	β-Dihydrocarvonecarboxamide	EtOH	0.9340	18.5	71.2	(328)
$C_{13}H_{15}NO_3$	Camphorylidenecyanoacetic acid††	$CHCl_3$	1.052		223.4	(613)
$C_{15}H_{19}NO_3$	Ethyl camphorylidenecyanoacetate	$CHCl_3$	1.012		201.2	(613)
$C_{15}H_{21}NO_3$	Ethyl cyanocamphoracetate‡‡		1.09		79.44	(810)
$C_{18}H_{20}O_3$	Camphorylidenephenylacetic acid§§	$CHCl_3$	1.0072		233.3	(613)

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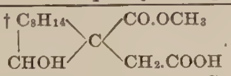
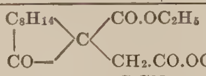
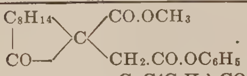
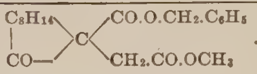
* Mutarotation.

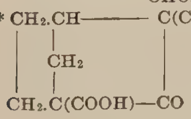
† 

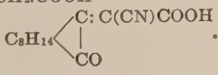
‡ $[\alpha]_{5461}$.

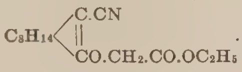
§ 

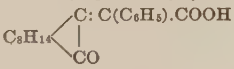
‖ 

¶ 

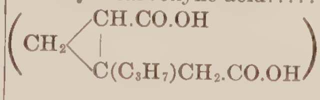
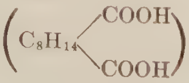
** 

†† 

‡‡ 

§§ 

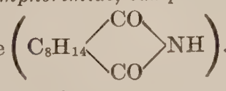
DICARBOXYLIC ACIDS

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
	Thujadicarboxylic acid and derivatives					
$C_9H_{12}O_3$	α-Thujadicarboxylic anhydride	Et_2O	*4.069*	17	10.1	(2022)
		$CHCl_3$	*2.642*	13	8.43	
$C_9H_{14}O_4$	α-Thujadicarboxylic acid  $\left(CH_2\begin{cases}CH.CO.OH\\ C(C_3H_7)CH_2.CO.OH\end{cases}\right)$	Et_2O	*4.991*		105.1	(2022)
		AcOH	*4.9177*		133.2	
		$CHCl_3$	*2.8726*		171.5	
		MeOH	*4.7043*		104.0	
		H_2O	*0.7323*		135.1	
		H_2O	*3.805*	18	−5.3	
		H_2O	*1.90*		−7.1	
	Ammonium salt	H_2O	*0.793*	17	15.2	(2022)
$C_9H_{15}NO_3$	α-Thujadicarboxylic monoamide	MeOH	*3.777*	15	54.5	(2022)
	Ammonium α-thujadicarboamate	H_2O	*1.713*	17	−17.6	(2022)
		MeOH	*4.694*	18	9.2	
$C_{11}H_{18}O_4$	Dimethyl α-thujadicarboxylate		1.054	18	142.5	(2022)
		Et_2O	*4.748*	20	142.1	
		Et_2O	*10.86*	20	139.2	
			1.0535	20	142.5	(2123)
$C_{13}H_{22}O_4$	Diethyl α-thujadicarboxylate		1.019	19	114.1	(2022)
		Et_2O	*5.135*	18	115.9	
		Et_2O	*10.073*	18	106.0	
$C_{15}H_{26}O_4$	Di-*n*-propyl α-thujadicarboxylate		0.9973	12	84.7	(2022)
		Et_2O	*6.786*	17	85.2	
$C_{16}H_{20}O_4$	Benzyl hydrogen α-thujadicarboxylate	Et_2O	*4.566*	17	34.7	(2022)
$C_{17}H_{30}O_4$	Diisobutyl α-thujadicarboxylate		0.991	12	77.62	(2022)
		Et_2O	*5.577*	12	71.6	
		Et_2O	*13.709*	12	73.0	
$C_{19}H_{34}O_4$	Diisoamyl α-thujadicarboxylate		0.9924	15	73.5	(2022)
		Et_2O	*4.4314*	16	73.1	
	Fenchocamphoric acid and derivatives					
$C_{10}H_{14}O_3$	*cis-d*-Isofenchocamphoric anhydride	C_6H_6	*10.48*	18.5	13.33	(1858)
$C_{10}H_{15}NO_2$	*d-cis*-Isofenchocamphoric imide	EtOH	*10.35*	18	−12.73	(1858)
$C_{10}H_{16}O_4$	Isofenchocamphoric acid	Et_2O	2.603	11	−12.75	(2130)
	l-cis-Isofenchocamphoric acid	EtOH	*9.3*	21	−14.54	(1858)
	d-trans-Isofenchocamphoric acid	EtOH	*10*	21	4.21	
$C_{10}H_{17}NO_3$	α-Amino-*trans-d*-isofenchocamphoric acid	EtOH	*1.57*	18	7.98	(1858)
	β-Amino-*trans-d*-isofenchocamphoric acid	EtOH	*1.68*	17	9.71	
	β-Amino-*cis-d*-isofenchocamphoric acid	EtOH	*8.6*	17	8.91	(1858)
	α-Amino-*cis-l*-isofenchocamphoric acid	EtOH	*1.7*	20	−11.18	
$C_{10}H_{18}N_2O_2$	*d-trans*-Isofenchocamphodiamide	EtOH	*6*	17	−6.18	(1858)
$C_{12}H_{20}O_4$	Dimethyl *trans-l*-isofenchocamphorate		1.0471_4^{20}	16	1.18	(1858)
	Dimethyl *cis-d*-isofenchocamphorate		1.0470_4^{20}	21	19.17	
$C_{14}H_{24}O_4$	Diethyl *d-trans*-isofenchocamphorate		1.0057	20	−1.05	(1858)
	Diethyl *l-cis*-isofenchocamphorate		1.0073	20	−11.16	
$C_{22}H_{26}N_2O_2$	*l-trans*-Isofenchocamphoric dianilide	EtOH	*7.69*	15	20.69	(1858)
	d-cis-Isofenchocamphoric dianilide	EtOH	*2.39*	18.5	26.26	(1858)
	Camphoric acid and camphorates					
$C_{10}H_{13}BrO_3$	β-Bromocamphoric anhydride	Me_2CO	5	9	−2.8	(41)
$C_{10}H_{14}O_3$	Camphoric anhydride; *cf.* (57, 833, 1388)	C_6H_6	*0.7705*		−7.12	(1449)
$C_{10}H_{15}BrO_4$	β-Bromocamphoric acid	EtOH	5	11	39.3	(41)
$C_{10}H_{16}O_4$	Camphoric acid  $\left(C_8H_{14}\begin{cases}COOH\\ COOH\end{cases}\right)$; for camphorates, *cf.* (1162, 2021)	$CHCl_3$	2.5	21	46.4	(904)
		$CHCl_3$	5.0	21	46.0	(833)
		Me_2CO	*15*	20	50.81	
		AcOH	*15*	20	46.66	
	Ammonium salt	H_2O	*10*	20	17.87	(833)
	Barium salt	H_2O	*10*	20	12.21	(833)
	Calcium salt	H_2O	*10*	20	17.69	(833)
	Lithium salt	H_2O	*10*	20	20.08	(833)
	Magnesium salt	H_2O	*10*	20	19.70	(833)
	Potassium salt	H_2O	*10*	20	14.48	(833)
	Sodium salt	H_2O	*10*	20	16.91	(833)
$C_{10}H_{16}O_4$	Isocamphoric acid; *cf.* (57, 686, 1388)	EtOH	*10*		−47.6	(1524)
$C_{11}H_{17}BrO_4$	Monomethyl β-bromocamphorate	Me_2CO	4.79	10	53.6	

Camphoric acid and camphorates.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{11}H_{18}O_4$	Allomethyl hydrogen camphorate				43.55	(788)
	Orthomethyl hydrogen camphorate				51.52	
	Methyl hydrogen camphorate	$CHCl_3$	*5.0*	23	57.71	(408)
		$CHCl_3$	*2.5*	23	58.50	
	α-Methyl β-hydrogen isocamphorate	EtOH	10		−57.9	(1522)
	α-Methyl hydrogen isocamphorate	EtOH	*10*		−58.4	(1524)
	β-Methyl hydrogen isocamphorate	EtOH	*10*		−53.1	
$C_{12}H_{20}O_4$	Dimethyl camphorate		1.0747^{20}_{4}	22	48.16	(251); *cf.* (788; 2101)
$C_{12}H_{20}O_4$	Dimethyl isocamphorate		1.073^{20}_{4}	21	−65.2	(1522)
		EtOH	*10*		−63.6	(1524)
$C_{12}H_{20}O_4$	Ethyl hydrogen camphorate	$CHCl_3$	*5*	23	38.72	(408)
		$CHCl_3$	*2.5*	23	39.8	
	Alloethyl hydrogen camphorate		1.1004		23.9	(687)
	Orthoethyl hydrogen camphorate		1.1133		39.18	
$C_{12}H_{20}O_4$	Orthoethyl hydrogen isocamphorate		1.1156		−49.51	(687)
$C_{13}H_{22}O_4$	Allomethyl orthoethylcamphorate		1.0528^{22}_{4}	22.2	38.43	(251)
	Orthomethyl alloethylcamphorate		1.0448^{22}_{4}	22.2	45.49	
$C_{13}H_{22}O_4$	*n*-Propyl hydrogen camphorate	$CHCl_3$	*5.0*	23	38.76	(408)
		$CHCl_3$	*2.5*	23	38.56	
$C_{14}H_{24}O_4$	Diethyl camphorate		1.0301	19.6	36.30	(251); *cf.* (687)
$C_{14}H_{24}O_4$	Diethyl isocamphorate		1.0473		−48.53	(687)
$C_{14}H_{24}O_4$	*n*-Butyl hydrogen camphorate	$CHCl_3$	*5.0*	23	35.6	(408)
		$CHCl_3$	*2.5*	23	36.24	
$C_{16}H_{20}O$	Phenyl hydrogen camphorate	$CHCl_3$	*2.5*	23	45.38	(408)
$C_{17}H_{20}O_5$	Orthoaldehydophenyl hydrogen camphorate	$CHCl_3$	*2.5*	23	48.1	(408)
$C_{17}H_{22}O_4$	Orthotolyl hydrogen camphorate	$CHCl_3$	2.5	21	45.0	(904); *cf.* (408)
		$CHCl_3$	5.0	21	45.2	
$C_{18}H_{38}N_2O_4$	Dibutylamine camphorate	$CHCl_3$	*2.5*	20	39.9	(408)
$C_{20}H_{22}O_4$	α-Naphthyl hydrogen camphorate	$CHCl_3$	*2.5*	23	34.24	(408)
	β-Naphthyl hydrogen camphorate	$CHCl_3$	*2.5*	23	53.28	(408)
$C_{20}H_{24}O_5$	Orthoacetylvinylphenyl hydrogen camphorate	$CHCl_3$	*2.5*	23	30.04	(408)
$C_{20}H_{26}O_5$	Eugenyl hydrogen camphorate	$CHCl_3$	2.5	21	32.0	
		$CHCl_3$	5.0	21	32.7	(904)
$C_{20}H_{26}O_5$	Isoeugenyl hydrogen camphorate	$CHCl_3$	2.5	21	38.0	(904)
		$CHCl_3$	5.0	21	38.6	
$C_{20}H_{34}O_4$	*o*-Menthyl hydrogen camphorate	C_6H_6	1.567	20	−16.6	(344)
$C_{22}H_{24}O_5$	2-Aceto-α-naphthyl hydrogen camphorate	$CHCl_3$	*2.5*	23	38.00	(408)
$C_{24}H_{32}N_2O_4$	Di-*p*-toluidine camphorate	$CHCl_3$	2.5	21	24.0	(904); *cf.* (408)
		$CHCl_3$	5.0	21	22.9	
$C_{25}H_{26}O_5$	Ortho-β-benzoylvinylphenyl hydrogen camphorate	$CHCl_3$	*2.5*	23	49.44	(408)
$C_{26}H_{32}N_2O_6$	Di-*p*-aminoacetophenone camphorate	$CHCl_3$	2.5	21	19.4	(904)
		$CHCl_3$	5.0	21	19.2	
$C_{26}H_{48}O_4$	Cetyl hydrogen camphorate	$CHCl_3$	5.0	20	20.43	(908)
$C_{27}H_{26}O_5$	2-Benzoyl-α-naphthyl hydrogen camphorate	$CHCl_3$	*2.5*	23	52.82	(1553)
$C_{36}H_{36}N_2O_6$	Di-*p*-aminobenzophenone camphorate	$CHCl_3$	2.5	21	12.4	(904); *cf.* (408)
		$CHCl_3$	5.0	21	12.2	
$C_{40}H_{76}O_4$	Myricyl hydrogen camphorate	$CHCl_3$	2.5	20	14.85	(908)
		$CHCl_3$	5.0	20	14.29	

Camphorimide, camphoramide and camphoramic acid and derivatives

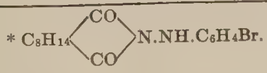
Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{15}NO_2$	Camphorimide  $\left(C_8H_{14}\langle{}^{CO}_{CO}\rangle NH\right)$	Me_2CO			−10.1	(2212, 1997)
		$CHCl_3$	20		5.45	
		$CHCl_3$	5		1.55	
$C_{10}H_{17}NO_3$	α-Camphoramic acid ($HO.CO.C_8H_{14}.CO.NH_2$)	Me_2CO			45	(2212)
$C_{10}H_{18}N_2O_2$	Camphoramide ($C_8H_{14}(CO.NH_2)_2$)	$CHCl_3$			−10.6	(758.5)
$C_{11}H_{17}NO_2$	Methylcamphorimide	Me_2CO	2.3	20	7.26	(2212)
$C_{11}H_{19}NO_3$	*N*-Methyl-α-camphoramic acid	Me_2CO	2.3	20	33.24	(2212)
$C_{11}H_{19}NO_3$	α-Methyl β-camphoramate	EtOH		27	57.25	(807)
	β-Methyl α-camphoramate	EtOH		25	23.33	

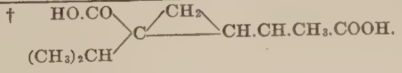
Camphorimide, camphoramide and camphoramic acid and derivatives.—(Continued)

Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{11}H_{19}NO_3$	β-Methyl isocamphoramate	EtOH	*10*		−54.4	(1524)
	α-Methyl β-isocamphoramate	EtOH	10		−60.05	(1522)
$C_{12}H_{19}NO_2$	*N*-Ethylcamphorimide	Me_2CO	2.3	20	8.87	(2212)
$C_{12}H_{21}NO_3$	*N*-Ethyl-α-camphoramic acid	Me_2CO	2.3	20	17.1	(2212)
$C_{13}H_{19}NO_2$	*N*-Allylcamphorimide	Me_2CO	2.3	20	7.95	(2212)
$C_{13}H_{21}NO_3$	*N*-Allyl-α-camphoramic acid	Me_2CO	2.3	20	13.54	(2212)
$C_{13}H_{21}NO_2$	*n*-Propylcamphorimide	Me_2CO	2.3	20	10.9	(2212)
$C_{13}H_{23}NO_3$	*N*-*n*-Propyl-α-camphoramic acid	Me_2CO	2.3	20	18.45	(2212)
$C_{14}H_{23}NO_2$	*N*-*n*-Butylcamphorimide	Me_2CO	2.3	20	12.8	(2212)
$C_{14}H_{25}NO_3$	*N*-Diethyl-α-camphoramic acid	EtOH	*8.78*	20	19.29	(685)
$C_{14}H_{25}NO_3$	*N*-β-Butyl-α-camphoramic acid	EtOH	*6.98*	20	28.80	(685)
$C_{14}H_{25}NO_3$	β-*n*-Butyl-α-camphoramic acid	Me_2CO	2.3	20	15.8	(2212)
$C_{15}H_{25}NO_2$	*N*-*n*-Amylcamphorimide	Me_2CO	2.3	20	7.7	(2212)
$C_{15}H_{27}NO_3$	*N*-*n*-Amyl-α-camphoramic acid	Me_2CO	2.3	20	18.9	(2212)
$C_{16}H_{18}BrNO_2$	*N*-2-Bromophenylcamphorimide	Me_2CO	2.3	20	13.3	(2212)
	N-3-Bromophenylcamphorimide	Me_2CO	2.3	20	15.4	
	N-4-Bromophenylcamphorimide	Me_2CO	2.3	20	15.7	
$C_{16}H_{18}ClNO_2$	*N*-2-Chlorophenylcamphorimide	Me_2CO	2.3	20	14.1	(2212)
	N-3-Chlorophenylcamphorimide	Me_2CO	2.3	20	16.2	
	N-4-Chlorophenylcamphorimide	Me_2CO	2.3	20	16.2	
$C_{16}H_{18}N_2O_4$	*N*-3-Nitrophenylcamphorimide	Me_2CO	2.3	20	1.7	(2212)
$C_{16}H_{19}BrN_2O_5$	*N*-4-Bromo-3-nitrophenyl-α-camphoramic acid	EtOH	1.50		−48.4	(2211)
$C_{16}H_{20}BrNO_3$	*N*-4-Bromophenyl-α-camphoramic acid	EtOH	2.77		47.0	(211)
$C_{16}H_{20}BrNO_3$	*N*-2-Bromophenyl-α-camphoramic acid	Me_2CO	2.3	20	−11.8	(2212)
	N-3-Bromophenyl-α-camphoramic acid	Me_2CO	2.3	20	33.2	
	N-4-Bromophenyl-α-camphoramic acid	Me_2CO	2.3	20	37.8	
$C_{16}H_{20}ClNO_3$	*N*-2-Chlorophenyl-α-camphoramic acid	Me_2CO	2.3	20	−16.4	(2212)
	N-3-Chlorophenylcamphoramic acid	Me_2CO	2.3	20	37.0	
	N-4-Chlorophenylcamphoramic acid	Me_2CO	2.3	20	40.5	
$C_{16}H_{20}N_2O_5$	*N*-3-Nitrophenyl-α-camphoramic acid	Me_2CO	2.3	20	32.0	(2212)
$C_{16}H_{21}BrN_2O_3$	*N*-4-Bromo-3-aminophenyl-α-camphoramic acid	EtOH	1.96		40.7	(2211); *cf.* (2212)
$C_{16}H_{21}NO_4$	*N*-4-Hydroxyphenyl-α-camphoramic acid	Me_2CO	2.3	20	49.2	(2212)
	N-*cis*-Hydroxyphenyl-α-camphoramic acid			16	46.36	(1197)
	N-*trans*-Hydroxyphenyl-α-camphoramic acid			16	13.48	(1197)
$C_{16}H_{22}N_2O_3$	*N*-3-Aminophenyl-α-camphoramic acid	Me_2CO	2.3	20	39.9	(2212)
$C_{16}H_{27}NO_2$	*N*-*n*-Hexylcamphorimide	Me_2CO	2.3	20	10.8	(2212)
$C_{16}H_{29}NO_3$	*N*-*n*-Hexyl-α-camphoramic acid	Me_2CO	2.3	20	16.9	(2212)
$C_{17}H_{21}NO_2$	*N*-*o*-Tolylcamphorimide	Me_2CO	2.3	20	15.7	(2212)
	N-*m*-Tolylcamphorimide	Me_2CO	2.3	20	17.6	
	N-*p*-Tolylcamphorimide	Me_2CO	2.3	20	12.7	
$C_{17}H_{23}NO_3$	*N*-*o*-Tolyl-α-camphoramic acid	Me_2CO	2.3	20	33.9	(2212)
	N-*m*-Tolyl-α-camphoramic acid	Me_2CO	2.3	20	31.0	
	N-*p*-Tolyl-α-camphoramic acid	Me_2CO	2.3	20	37.0	
$C_{17}H_{24}N_2O_3$	α-Methyl β-phenylhydrazinocamphorate	EtOH		26	42.01	(807)
$C_{18}H_{23}NO_3$	*N*-4-Ethoxyphenylcamphorimide	Me_2CO	2.3	20	18.5	(2212)
$C_{18}H_{25}NO_4$	*N*-4-Ethoxyphenyl-α-camphoramic acid	Me_2CO	2.3	20	39.5	(2212)
$C_{18}H_{33}NO_3$	*N*-*d*-Octyl-α-camphoramic acid	EtOH	*6.49*	20	24.45	(685)
$C_{20}H_{21}NO_2$	*N*-α-Naphthylcamphorimide	Me_2CO	2.3	20	26.34	(2212)
	N-β-Naphthylcamphorimide	Me_2CO	2.3	20	18.0	
$C_{20}H_{23}NO_3$	*N*-α-Naphthyl-α-camphoramic acid	Me_2CO	2.3	20	7.46	(2212)
	N-β-Naphthyl-α-camphoramic acid	Me_2CO	2.3	20	64.9	
$C_{20}H_{28}N_2O_3$	β-Camphornitrilic acid anhydride ($(CN.C_8H_{14}.CO)_2O$)	$CHCl_3$	1.017		52.4	(608)
$C_{22}H_{25}N_3O_3$	*N*-4-Benzeneazophenyl-α-camphoramic acid ($C_6H_5.N_2.C_6H_4.NH.CO.C_8H_{14}.COOH$)	EtOH	2.3	20	87.7	(2212); *cf.* (2211)
$C_{36}H_{47}Cl_3N_4O_6$	Trichlorobutylidenebis-3-aminophenyl-α-camphoramic acid ($CH_3.C.Cl_2.CHCl.CH(NH.C_6H_4.NH.CO.C_8H_{14}.COOH)_2$)	Me_2CO	2.555		27.4	(2212)

Camphoryloxime, hydrazide, etc.

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{14}BrNO_3$	β-Bromocamphoryloxime	$CHCl_3$	2.20	13	10.2	(1286.5)
$C_{10}H_{15}NO_3$	Camphoryloxime $\left(C_8H_{14}{<}\begin{smallmatrix}CO\\CO\end{smallmatrix}{>}NOH\right)$	$C_2H_4Cl_2$	*44.32*	17.4	14.09	(1599)
		EtOH	1.8		10	(277)
$C_{12}H_{14}NO_4$	Acetylcamphoryloxime	EtOH	2		4.25	(277)
$C_{12}H_{16}BrNO_4$	Acetyl-β-bromocamphoryloxime	Me_2CO	2.36	15	3	(1286.5)
	Acetyl-π-bromocamphoryloxime	Me_2CO	51.4	13	1.3	
$C_{17}H_{18}BrNO_4$	Benzoyl-β-bromocamphoryloxime	Me_2CO	1.57	12	11	(1286.5)
	Benzoyl-π-bromocamphoryloxime	Me_2CO	3.4	13	46.3	
$C_{20}H_{28}N_2O_5$	Camphoryloxime anhydride	Me_2CO	2	14	26.7	(1286.5)
$C_{30}H_{42}N_2O_8$	*sesqui*-Camphorylhydroxylamine	Me_2CO	3.22	13	33	(1286.5)
$C_{16}H_{19}N_3O_3$	*N*-Nitrosocamphoryl phenylhydrazide	$CHCl_3$	1.71		14.1	(2211)
$C_{16}H_{19}N_3O_4$	*N*-Nitrocamphoryl phenylhydrazide	$CHCl_3$	1.43		16.1	(2211)
$C_{16}H_{19}BrN_2O_2$	Camphoryl 4-bromophenylhydrazide*	EtOH	0.981		26.9	(2211)
$C_{16}H_{17}Br_2N_3O_3$	*N*-Nitrosocamphoryl dibromophenylhydrazide	$CHCl_3$	1.11		19.0	(2211)
$C_{16}H_{17}Br_2N_3O_4$	*N*-Nitrocamphoryl dibromophenylhydrazide	$CHCl_3$	2.1		10.9	(2211)
$C_{16}H_{18}BrN_3O_3$	*N*-Nitrosocamphoryl 4-bromophenylhydrazide	$CHCl_3$	1.55		18.1	(2211)
$C_{16}H_{18}BrN_3O_4$	*N*-Nitrocamphoryl 4-bromophenylhydrazide	$CHCl_3$	1.72		14.0	(2211)
	Homocamphoric acid and esters					
$C_{12}H_{20}O_4$	α-Methylhomocamphoric acid	EtOH			26.31	(1432)
	β-Methylhomocamphoric acid	EtOH			38.12	
$C_{13}H_{22}O_4$	α-Ethyl hydrogen homocamphorate	EtOH	4.18	17	55.8	(1553)
$C_{13}H_{22}O_4$	Ethyl-β-homocamphoric acid	EtOH			39.65	(1433)
$C_{19}H_{26}O_4$	α-Ethyl β-phenylhomocamphorate	EtOH	9.64	19	27.58	(1553)
	Other dicarboxylic acids					
$C_9H_{12}O_3$	Caryophyllenic anhydride		1.1399^{20}	20	−28	(1928)
$C_{10}H_{16}O_4$	*d*-Homotanacetonedicarboxylic acid†	MeOH	20		10.25	(1920)
$C_{11}H_{18}O_4$	Methyl caryophyllenate		1.0456	20	44	(1928)
	AMINES AND IMINES					
	MONOAMINES AND HYDROXYAMINES					
$C_{10}H_{17}N$	1-Aminocamphene	EtOH	1.78	22	59.7	(578)
		C_6H_6	1.93	22	43.4	
$C_{10}H_{17}N$	Camphenamine	MeOH	*15.7*	18	4.11	(398)
$C_{10}H_{19}N$	Camphidine	C_6H_6	10	20	23.9	(1997)
$C_{11}H_{23}NO$	α-Aminohomocampholic alcohol	C_6H_6	0.93	21	68.71	(1553)
		EtOH	5.03	15	78.86	
	KETOAMINES AND IMINES					
	Iminocamphor and derivatives					
$C_{10}H_{15}NO_2$	α-Iminocamphor $\left(C_8H_{14}{<}\begin{smallmatrix}C:NH\\ \vert\\ CO\end{smallmatrix}\right)$	EtOH	1.67		77.8	(593)
$C_{16}H_{18}BrNO$	*o*-Bromophenyliminocamphor	$CHCl_3$	0.191	31	429.4‡	(1952)
		MeOH	0.182	31.5°	327.2‡	
	m-Bromophenyliminocamphor	$CHCl_3$	0.700	31	415.5‡	
		MeOH	0.734	31	336.7‡	
	p-Bromophenyliminocamphor	$CHCl_3$	0.612	30	534.0‡	
		MeOH	0.600	30	280.2‡	
$C_{16}H_{18}ClNO$	*o*-Chlorophenyliminocamphor	$CHCl_3$	0.318	28.0	161.9‡	(1952)
		MeOH	0.473	31.0	176.6‡	
	m-Chlorophenyliminocamphor	$CHCl_3$	0.335	27.5	476.7‡	
		MeOH	0.402	26.5	459.0‡	
$C_{16}H_{18}ClNO$	*p*-Chlorophenyliminocamphor	$CHCl_3$	0.415		642	(611)
$C_{16}H_{19}NO$	Phenyliminocamphor	MeOH	0.462	26.5	606.8	(1952)
		MeOH	0.462	27.0	596.1	
		$CHCl_3$	0.505		726	(611)
$C_{16}H_{19}NO_2$	*m*-Hydroxyphenyliminocamphor	$CHCl_3$	0.412		630	(611)
	p-Hydroxyphenyliminocamphor	$CHCl_3$	0.231		1363	


* $C_8H_{14}{<}\begin{smallmatrix}CO\\CO\end{smallmatrix}{>}N.NH.C_6H_4Br.$


† $\begin{smallmatrix}HO.CO\\(CH_3)_2CH\end{smallmatrix}{>}C\overset{CH_2}{\triangle}CH.CH.CH_3.COOH.$

‡ Mutarotation.

Iminocamphor and derivatives.—(Continued)

Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{16}H_{20}N_2O$	Phenyliminocamphor-α-oxime	$CHCl_3$	1.043		304.4	(608)
	Phenyliminocamphor-β-oxime	$CHCl_3$	1.058		335.4	
$C_{17}H_{21}NO$	*o*-Tolyliminocamphor	$CHCl_3$	0.739	32	464.4*	(1952)
		MeOH	0.764	34	398.4*	
	m-Tolyliminocamphor	$CHCl_3$	0.326	29.5	660.7*	
		MeOH	0.454	29.5	689.7*	
	p-Tolyliminocamphor	MeOH	0.795	30	474.5*	
$C_{17}H_{21}NO_2$	*o*-Methoxyphenyliminocamphor	$CHCl_3$	0.321	28	228.9*	(1952)
	p-Methoxyphenyliminocamphor	$CHCl_3$	0.388		1223	(611)
$C_{20}H_{21}NO$	α-Naphthyliminocamphor	$CHCl_3$	0.340	32.0	609.6	(1952)
		MeOH	0.603	32.0	558.5	
	β-Naphthyliminocamphor	$CHCl_3$	0.485	31.0	686.0	
		MeOH	0.573		641.6	
$C_{20}H_{25}NO$	*ar*-Tetrahydro-α-naphthyliminocamphor	MeOH	0.843	18	393.2	(1952)
		$CHCl_3$	0.808	18	450.9	
$C_{22}H_{23}N_3O$	*p*-Benzeneazophenyliminocamphor	$CHCl_3$	0.280	23.5	580.8	(1952)
		MeOH	0.180		568.4	
$C_{23}H_{24}N_2O_2$	Benzoylphenyliminocamphor-α-oxime	$CHCl_3$	1.038		314.6	(608)
	Benzoylphenyliminocamphor-β-oxime	$CHCl_3$	1.059		308.4	
$C_{23}H_{25}N_3O_2$	Phenyliminocamphor-α-oxime-phenylurethane	$CHCl_3$	0.975		207.7	(608)
	Phenyliminocamphor-β-oxime-phenylurethane	$CHCl_3$	8.866		184.7	
$C_{26}H_{32}N_2O_2$	*m*-Phenylenebisiminocamphor	MeOH	0.097	30.5	634.1	(1952)
		$CHCl_3$	0.395	28.0	671.0	
$C_{26}H_{32}N_2O_2$	*p*-Phenylenebisiminocamphor	$CHCl_3$	0.624		1509	(611)
		$CHCl_3$	0.143	24.5	1507	(1953)
		MeOH	0.178	21.7	1240	
		EtOH	0.132	21.7	1309	
$C_{27}H_{34}N_2O_2$	*m*-Tolylenebisiminocamphor	$CHCl_3$	0.033	20	333.3	(1954)
		MeOH	0.034	20	248.5	
$C_{30}H_{34}N_2O_2$	1, 4-Naphthylenebisiminocamphor	$CHCl_3$	0.0533	18.1	1801	(1953)
		MeOH	0.0181	18.4	1994	
		EtOH	0.0168	18.4	2696	
		Py	0.0244	30	2955	
$C_{32}H_{36}N_2O_2$	*p, p'*-Diphenylenebisiminocamphor					
	(green form)	$CHCl_3$	0.257	35	1140	(1955)
	(yellow form)	$CHCl_3$	0.473	35	1132	
		MeOH	0.908	29	1046	
$C_{32}H_{37}N_3O_2$	*p, p'*-Bisiminocamphordiphenylamine	$CHCl_3$	0.130	23	2300	(1955)
		$CHCl_3$	0.0364	30	2370	
		MeOH	0.0554	23	2500	
		Me_2CO	0.0376	19	2646	
		EtOH	0.0440	19	2875	
		Py	0.1084	30	2685	
$C_{34}H_{40}N_2O_2$	*o, o'*-Ditolylenebisiminocamphor					
	(green isomeride)	$CHCl_3$	0.128	29	773	(1955)
		MeOH	0.115	30	645	
	(yellow isomeride)	$CHCl_3$	0.564	29	789	
		Me_2CO	0.271	21	736	
		MeOH	0.0834	29	683	
$C_{34}H_{40}N_2O_4$	*o, o'*-Dimethoxydiphenylenebisiminocamphor	$CHCl_3$	0.167	22	371	(1955)
		MeOH	0.264	22	290	
	Derivatives of aminocamphor					
$C_{10}H_{14}N_2O$	Diazocamphor	$CHCl_3$	1.642		134.8	(614)
$C_{10}H_{15}N_3O$	Camphorylazoimide	C_6H_6	1.04		−351.5	(593)
		EtOH	1.04		−284.2	
		Me_2CO	1.045		−279.4	
		$CHCl_3$	1.035		−246.2	
$C_{10}H_{18}N_2O$	α-Aminocamphoroxime	EtOH	*1*	18	60.5	(1173)
$C_{10}H_{19}ClN_2O$	α-Aminocamphoroxime hydrochloride	H_2O	*1*	16	36.7	(1173)

* Mutarotation.

Derivatives of aminocamphor.—(*Continued*)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{19}N_3$	Aminocamphorhydrazone	$CHCl_3$	0.966		250.2	(604)
$C_{16}H_{21}NO_3S$	Benzenesulfonylaminocamphor	$CHCl_3$	0.993		85.6	(604)
$C_{16}H_{23}N_3$	Aminocamphorphenylhydrazone	$CHCl_3$	0.951		176.2	(604)
$C_{17}H_{23}NO_3S$	Benzenesulfonylmethylaminocamphor	$CHCl_3$	1.026		85.3	
$C_{17}H_{23}NO_3S$	*p*-Toluenesulfonylaminocamphor*	$CHCl_3$	1.069		87.3	(604)
$C_{18}H_{25}NO_3S$	*p*-Toluenesulfonylmethylaminocamphor	$CHCl_3$	1.021		81.6	(604)
$C_{20}H_{31}NO_4S$	Camphor-β-sulfonylaminocamphor†	$CHCl_3$	1.037		−35.2	(604)
$C_{24}H_{26}N_2O_3$	Dibenzoylaminocamphoroxime‡	EtOH	1.33	18	104.8	(1173)
	Anilinocamphor and derivatives					
$C_{16}H_{20}BrNO$	*o*-Bromophenylaminocamphor	$CHCl_3$	0.203	19	76.3	(1952)
		MeOH	0.140	19	71.1	
	m-Bromophenylaminocamphor	$CHCl_3$	2.842	19	86.2	
		MeOH	0.162	19	64.6	
	p-Bromophenylaminocamphor	$CHCl_3$	0.267	19	93.5§	
		MeOH	0.180	19	67.8§	
$C_{16}H_{20}ClNO$	*p*-Chlorophenylaminocamphor	$CHCl_3$	0.093		694	(611)
$C_{16}H_{21}NO$	Phenylaminocamphor	$CHCl_3$	0.090		127	(611)
$C_{16}H_{21}NO_2$	*p*-Hydroxyphenylaminocamphor	$CHCl_3$	0.0978		83	(611)
$C_{17}H_{23}NO$	*o*-Tolylaminocamphor	MeOH	0.221	17	58.9§	(1952)
		$CHCl_3$	0.280	17	85.7§	
	m-Tolyaminocamphor	MeOH	0.323	17	83.7§	
		$CHCl_3$	0.254	17	128.7§	
	p-Tolyaminocamphor	MeOH	0.244	18	57.5§	
		$CHCl_3$	0.272	17	99.2§	
$C_{17}H_{23}NO_2$	*o*-Methoxyphenylaminocamphor	MeOH	1.171	20	53.6	(1952)
		$CHCl_3$	1.159	20	99.7	
$C_{17}H_{23}NO_2$	*p*-Methoxyphenylaminocamphor	$CHCl_3$	0.092		68	(611)
$C_{18}H_{26}N_2O_3$	*p*-Ethoxyphenylaminocamphor (hydroxyamino derivative)	$CHCl_3$	1.104		101.8	(611)
$C_{20}H_{23}NO$	α-Naphthylaminocamphor	$CHCl_3$	1.404	18	91.3	(1952)
		MeOH	1.540	16.8	71.77	
	β-Naphthylaminocamphor	$CHCl_3$	0.284	18	142.6	
		MeOH	0.284	18	125.0	
$C_{20}H_{27}NO$	*ar*-Tetrahydro-α-naphthylaminocamphor	MeOH	0.275	20	109.5	(1952)
		$CHCl_3$	0.407	20	117.1	
$C_{26}H_{36}N_2O_2$	*m*-Phenylenebisaminocamphor	$CHCl_3$	0.126	20	151.2	(1952)
		MeOH	0.114	20	118.3	
$C_{27}H_{38}N_2O_2$	*m*-Tolylenebisaminocamphor	$CHCl_3$	0.161	20	83.9	(1952)
		MeOH	0.177	20	91.6	
$C_{32}H_{40}N_2O_2$	*p*, *p′*-Diphenylenebisaminocamphor	$CHCl_3$	0.292	17	97.6	(1955)
		MeOH	0.065	17	76.9	
		Me_2CO	0.144	17	163.7	
	Camphorylcarbamide, carbimide and carbamic acid with isomers and derivatives					
$C_{11}H_{15}NO_2$	Camphorylcarbimide‖	$CHCl_3$	1.90		−124.5	(591)
$C_{11}H_{15}NOS$	Camphorylthiocarbimide	EtOH	0.907		−114.1	(600)
$C_{11}H_{16}Br_2N_2O_2$	Camphoryl-*N*-dibromo-ψ-carbamide	$CHCl_3$	0.973		30.9	(597)
$C_{11}H_{16}Cl_2N_2O_2$	Camphoryl-*N*-dichloro-ψ-carbamide¶	$CHCl_3$	0.54		26.5	(597)
$C_{11}H_{17}NOS_2$	Camphoryldithiocarbamic acid**	Me_2CO	1.05		21.5	(600)
$C_{11}H_{17}N_3O_3$	Camphorylnitroso-ψ-carbamide	$CHCl_3$	1.26		169.3	(591)
$C_{11}H_{18}N_2O_2$	Camphoryl-ψ-carbamide††	EtOH	1.84		−13.5	(591)
$C_{11}H_{18}N_2OS$	Camphorylthiocarbamide ($C_{10}H_{15}O.NH.CS.NH_2$)	$CHCl_3$	1.06		−44.9	(600)
$C_{12}H_{19}BrN_2O_2$	Camphorylmethylbromo-ψ-carbamide	$CHCl_3$	1.31		9.5	(597)
$C_{12}H_{19}NO_3$	Methyl camphorylcarbamate ($C_{10}H_{15}O.NH.CO.OCH_3$)	$CHCl_3$	1.03		43.5	(591)
$C_{12}H_{19}NOS_2$	Methyl camphoryldithiocarbamate‡‡	$CHCl_3$	4.18		114.6	(600)
$C_{12}H_{19}NO_2S$	Methyl camphorylthiocarbamide	$CHCl_3$	1.46		108.6	(600)
$C_{12}H_{20}N_2O_2$	Camphorylmethyl-ψ-carbamide	EtOH	3.25		6.9	(591)
$C_{13}H_{21}NO_3$	Ethyl camphorylcarbamate§§	$CHCl_3$	2.1		38.3	(591)
$C_{16}H_{26}N_2OS$	Camphorylpiperidylthiocarbamide	$CHCl_3$	1.25		26.6	(600)

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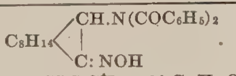
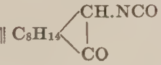
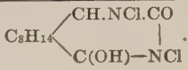
* $C_{10}H_{15}O.NH.SO_2.C_6H_4.CH_3$. † $C_{10}H_{15}O.NH.SO_2.C_{10}H_{15}O$.

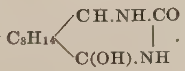
‡ 
$C_8H_{14}\langle\begin{smallmatrix}CH.N(COC_6H_5)_2\\ |\\ C{:}\,NOH\end{smallmatrix}$.

§ Mutarotation.

‖ 
$C_8H_{14}\langle\begin{smallmatrix}CH.NCO\\ |\\ CO\end{smallmatrix}$.

¶ 
$C_8H_{14}\langle\begin{smallmatrix}CH.NCl.CO\\ |\\ C(OH)-NCl\end{smallmatrix}$.

** $C_{10}H_{15}O.NH.CS.SH$.

†† 
$C_8H_{14}\langle\begin{smallmatrix}CH.NH.CO\\ |\\ C(OH).NH\end{smallmatrix}$.

‡‡ $C_{10}H_{15}O.NH.CS.S.CH_3$. §§ $C_{10}H_{15}O.NH.CO.O.C_2H_5$.

Camphorylcarbamide, carbimide and carbamic acid with isomers and derivatives.—(Continued)

Formula	Name	Solvent	d, C or %	t, °C	[α]$_D$	Lit.
$C_{16}H_{27}N_2O_2$	s-Camphorylpiperidylcarbamide*	$CHCl_3$	1.60		40.1	(591)
$C_{17}H_{22}N_2O_2$	Camphoryl phenyl-ψ-carbamide	$CHCl_3$			12.4	(595)
$C_{18}H_{21}NO_2S_2$	Benzoylcamphoryldithiocarbamic acid	$CHCl_3$	1.15		52.3	(600)
$C_{21}H_{32}N_2O_2$	Bornylcarbiminocamphor	$CHCl_3$	1.33		153.8	(593)
		C_6H_6	1.19		131.8	
		Me_2CO	1.40		121.0	
		EtOH	0.95		108.7	
$C_{21}H_{32}N_2O_3$	s-Dicamphorylcarbamide	$CHCl_3$	2.08		38.2	(591)
$C_{21}H_{32}N_2O_2S$	Dicamphorylthiocarbamide ($CS.(NH.C_{10}H_{15}O)_2$)	Me_2CO	1.93		54.3	(600)
$C_{23}H_{26}N_4O_2$	Camphordiazodiphenylcarbamide	Py	0.5		211.4†	(595)
	Camphorylsemicarbazide, isomers and derivatives					
$C_{11}H_{17}N_3O$	Camphoryl-ψ-semicarbazide anhydride	$CHCl_3$	0.505		−186.2	(592)
$C_{11}H_{19}N_3O_2$	Camphoryl-ψ-semicarbazide‡	H_2O	3.38		8.6	(592)
$C_{11}H_{20}N_4O_2$	Camphorylsemicarbazide oxime§ (1st isomeride)	Py	0.410		81.3	(594)
	(2nd isomeride)	Py	0.405		−37.7	
$C_{14}H_{23}N_3O_2$	*N*-Isopropylidene camphoryl-ψ-semicarbazone	$CHCl_3$	0.441		−187.8	(592)
$C_{16}H_{21}N_3O_3$	*N*-Furfurylidene camphoryl-ψ-semicarbazone	$CHCl_3$	0.402		502.2	(592)
		EtOH	0.922		100.5	
$C_{16}H_{22}N_4O_3$	*N*-Furfurylidenesemicarbazinocamphoroxime	$CHCl_3$	1.32		120.8	(594)
$C_{17}H_{21}N_3O_3$	*N*-Benzoquinone camphoryl-ψ-semicarbazone	Py	0.51		−1051	(592)
		Me_2CO	0.135		−1051	
		$CHCl_3$	0.033		−1067	
		EtOH	0.093		−545	
$C_{17}H_{22}BrN_5O_2.\frac{1}{2}EtOH$	*N*-*p*-Bromobenzenediazo-ψ-semicarbazinocamphor	EtOH	1.09		180.3	(588)
$C_{17}H_{22}ClN_5O_2$	*N*-*p*-Chlorobenzenediazo-ψ-semicarbazinocamphor	EtOH	0.389		212.2	(588)
$C_{17}H_{23}N_5O_2$	*N*-Benzenediazo-ψ-semicarbazinocamphor	EtOH	1.2		235.8	(588)
$C_{17}H_{23}N_3OS$	δ-Camphoryl β-phenylthiosemicarbazide	$CHCl_3$	1.26		59.5	(600)
	δ-Camphoryl α-phenylthiosemicarbazide	$CHCl_3$	0.85		58.5	
$C_{18}H_{22}N_4O_4$	*N*-*m*-Nitrobenzylidene camphoryl-ψ-semicarbazone	Py	0.808		20.4	(592)
		AcOH	1.13		84.1	
$C_{18}H_{22}N_3O_2$	*N*-Benzylidene camphoryl-ψ-semicarbazone	$CHCl_3$	2.01		420.6	(592)
$C_{18}H_{23}N_3O_3$	*N*-*o*-Hydroxybenzylidene camphorylsemicarbazone	$CHCl_3$	1.65		276.8	(592)
$C_{18}H_{23}N_5O_4$	*N*-*m*-Nitrobenzylidenesemicarbazinocamphoroxime	$CHCl_3$	0.547		126.5	(594)
$C_{18}H_{24}N_4O_2$	*N*-Benzylidenesemicarbazinocamphoroxime	$CHCl_3$	1.04		110.1	(594)
$C_{18}H_{25}N_5O_2$	*N*-*p*-Toluenediazo-ψ-semicarbazinocamphor	EtOH	1.39		222.2	(588)
$C_{19}H_{23}N_3O_4$	*N*-Piperonylidene camphoryl-ψ-semicarbazone	$CHCl_3$	1.21		450.0	(592)
$C_{19}H_{25}N_3O_3$	*N*-*p*-Methoxybenzylidene camphorylsemicarbazone	$CHCl_3$	1.96		440.2	(592)
$C_{19}H_{25}N_3O_4$	*N*-Vanillylidene camphoryl-ψ-semicarbazone	$CHCl_3$	0.918		308.6	(592)
$C_{20}H_{25}N_3O_2$	*N*-Cinnamylidene camphoryl-ψ-semicarbazone	CS_2	0.705		330.7	(592)
		$CHCl_3$	1.04		514.4	
		Me_2CO	0.804		161.6	
		Py	0.886		−53.7	
$C_{21}H_{29}N_3O_2$	*N*-Cuminylidene camphoryl-ψ-semicarbazone	$CHCl_3$	1.20		415	(592)
$C_{21}H_{31}N_3O_3$	*N*-Camphorquinone camphoryl-ψ-semicarbazone	$CHCl_3$	0.942		−314.2	(592)
$C_{25}H_{25}N_9O_3$	Bis-*p*-triazobenzoin camphoryl-ψ-semicarbazone	$CHCl_3$	0.698		556.3	(603)
		Py	1.0400		24.0	

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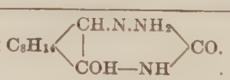
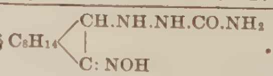
* $C_{10}H_{15}O.NH.CO.NC_5H_{10}$.

† Mutarotation.

‡ 

$C_8H_{14}\left\langle\begin{array}{l}CH.N.NH\\ \vert\\ COH{-}NH\end{array}\right\rangle CO.$

§ 

$C_8H_{14}\left\langle\begin{array}{l}CH.NH.NH.CO.NH_2\\ \vert\\ C{:}\ NOH\end{array}\right.$

Amino derivatives of epicamphor

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{17}NO$	Amino-*l*-epicamphor	EtOH	1.052		11.9	(608)
		C_6H_6	5.90	19	15.0	(237)
$C_{10}H_{18}N_2O$	Aminoepicamphoroxime	$CHCl_3$	1.248		−20.0	(608)
$C_{17}H_{21}NO$	Benzylideneaminoepicamphor	$CHCl_3$	0.410		298.5	(608)
$C_{17}H_{21}NO_2$	Benzoylaminoepicamphor	$CHCl_3$	1.411		−24.2	(608)
$C_{17}H_{23}NO_3S$	*p*-Toluenesulfonylaminoepicamphor	$CHCl_3$	1.00		−16.6	(604)
$C_{24}H_{26}N_2O_3$	Dibenzoylaminoepicamphoroxime	$CHCl_3$	0.972		−36.8	(608)
$C_{32}H_{36}N_8O_{14}$	Aminoepicamphoroximeepidihydrodicamphenepyrazine picrate	EtOH	0.492		250.9	(608)

Amino derivatives of methylenecamphor and benzylidenecamphor

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{17}H_{21}NO$	Anilino-*d*-methylenecamphor	C_6H_6	1.703		293.6*	(1675)
$C_{19}H_{25}NO$	*d*-α-Phenylethylamino-*d*-methylenecamphor	C_6H_6	0.788		−8.9*	(1675)
		EtOH	0.499		315.6*	
		AcOH	0.826		210.7*	
$C_{19}H_{25}NO$	*p*-Dimethylaminobenzylidenecamphor	EtOH	0.977	24	758	(804)
$C_{19}H_{26}ClNO$	*p*-Dimethylaminobenzylidenecamphor hydrochloride	H_2O	0.593	23	356	(804)
$C_{21}H_{29}NO$	*p*-Diethylaminobenzylidenecamphor	EtOH	0.990	19	740	(804)
$C_{21}H_{30}ClNO$	*p*-Diethylaminobenzylidenecamphor hydrochloride	H_2O	0.486	23	321	(804)

AMINO ACIDS

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_9H_{15}NO$	Aminodihydrocampholytic anhydride†	ligroin	10	30	72.8	(1528)
$C_{10}H_{16}N_2O_2$	*N*-Nitroso-α-camphidone	EtOH	2.5	23	−59.0	(1528)
	N-Nitroso-β-camphidone	EtOH	2.5	23	103	
$C_{10}H_{17}NO$	α-Camphidone‡	EtOH	5	25	33.9	(1528)
		C_6H_6	10	20	−37.2	(1997)
	β-Camphidone§	EtOH	5	24	63.2	(1528)
		C_6H_6	10	20	66.5	(1997)
$C_{20}H_{32}N_2O$	Di-β-camphidone anhydride	C_6H_6	10	20	207.4	(1996)

Compounds of phosphorus, arsenic and antimony

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{20}H_{31}O_6P$	Dicamphorylphosphinic acid ($(C_{10}H_{15}O_2)_2.PO.OH$)	$CHCl_3$	2.3852	20	151.1	(1459)
$C_{20}H_{31}AsO_6$	Dicamphorylarsinic acid ($((C_{10}H_{15}O)_2AsO.OH)$)	$CHCl_3$	1.96	20	186.6	(1457)
$C_{30}H_{45}Cl_2O_3Sb$	Tricamphorylstibine chloride ($((C_{10}H_{15}O)_3.SbCl_2)$)	$CHCl_3$	1.248	20	367.3	(1458)

IIDCB. The Molecule Contains Three or More Asymmetric Atoms Attached Respectively to Two, Three and Four Other Carbon Atoms

HYDROCARBONS AND HALOGEN DERIVATIVES

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{17}Cl$	Fenchyl chloride	EtOH	*11.79*		17.98	(1130); *cf.* (1127)
$C_{10}H_{17}Cl$	Bornyl chloride	CCl_4	68.27	17.4	6.92	(1599)

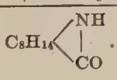
ALCOHOLS

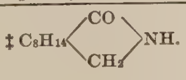
MONOHYDRIC ALCOHOLS

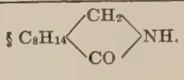
Fenchyl alcohol and derivatives

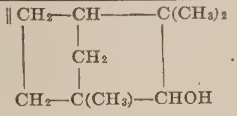
Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{10}H_{18}O$	Fenchyl alcohol‖	MeOH	5.135	20	−14.03	(306); *cf.* (780, 2110)
$C_{10}H_{18}O$	*d*-Isofenchyl alcohol	EtOH	*24.6*	10.5	18.17	(1858)
	L-*d*-Fenchyl alcohol	EtOH	*10.12*	15.5	12.69	
$C_{11}H_{20}O$	Homofenchyl alcohol (methylfenchol)	Et_2O	*30.18*	19	2.2	(2131)
$C_{11}H_{20}O$	Methylfenchyl alcohol	EtOH	2.45		11	(2231)
$C_{12}H_{20}O_2$	Fenchyl acetate		0.972^{15}_{15}		−58.08	(125,1)
$C_{16}H_{22}O$	*tert.*-Phenylfenchol	EtOH		18	45.65	(1199)
$C_{17}H_{24}O$	*tert.*-*o*-Tolylfenchol	EtOH		18	23.23	(1199)
	tert.-*p*-Tolylfenchol	EtOH			16.30	
	tert.-Benzylfenchol	EtOH		15	24.20	
$C_{22}H_{38}CrO_4$	Dimethylfenchyl chromate	CCl_4	10		−30.0¶	(2177)
$C_{24}H_{42}CrO_4$	Diethylfenchyl chromate	CCl_4	4		22.5¶	(2177)
$C_{30}H_{32}O_2$	Fenchyl triphenylacetate	PhMe	13.24	20	−17.30	(315)

* Mutarotation.

† 
$C_8H_{14}\langle NH, CO \rangle$.

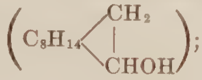
‡ 
$C_8H_{14}\langle CO, CH_2 \rangle NH$.

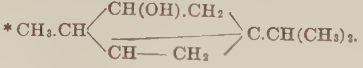
§ 
$C_8H_{14}\langle CH_2, CO \rangle NH$.

‖ 
$CH_2—CH——C(CH_3)_2$, CH_2, $CH_2—C(CH_3)—CHOH$

¶ $[\alpha]_{6870}$.

Thujyl alcohol and derivatives

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_{10}H_{18}O$	Thujol*			20	67.80	(**306**)
	α-Thujyl alcohol		0.925	20	69.82	(**1555,**
	β-Thujyl alcohol		0.9229	16	114.67	**1556**)
	l-Thujyl alcohol	PhMe	35.98	20	−9.12	(**313**)
	d-Thujyl alcohol		0.9187	20	116.93	
$C_{11}H_{20}O$	*tert.*-Homothujyl alcohol (solid isomeride)	Et_2O	*4.058*	15.5	−30.5	(**2022**)
		MeOH	*4.191*	12.0	−26	
	(liquid isomeride)	Et_2O	*5.226*	14	35.9	
		MeOH	*5.077*	13	33.4	
$C_{18}H_{22}O_4$	β-Thujyl hydrogen phthalate	EtOH	1.096		91.45	(**1556**); *cf.* (**1555**)
$C_{39}H_{44}N_2O_6$	Strychnine β-thujyl phthalate	C_6H_6	1.766		36.78	(**1556**)
	Borneol with alkyl and alkylidene derivatives and ethers					
$C_{10}H_{18}O$	*d*-Borneol  $\left(C_8H_{14}\left<\begin{matrix}CH_2\\ \vert\\ CHOH\end{matrix}\right.\right)$; *cf.* (**101, 787, 1034**)	$C_2H_4Cl_2$ EtOH MeOH	*23.73* 18 20	15.8 20 9.98	35.22 37.7 36.37	(**1599**) (**1489**) (**306**)
	l-Borneol	PhMe	11.6		−37.96	(**1629**); *cf.* (**1035, 787**)
	d-Isoborneol; *cf.* (**103.5, 784, 787, 790, 1034, 1446, 1449**)	EtOH	5.13		34.02	(**1629**)
		PhMe	11.5		21.32	
		MeOH	9.98	20	32.30	(**306**)
$C_{10}H_{18}S$	Thioborneol	AcOEt	*3.64*	15	21.08	(**2222**)
$C_{10}H_{19}NO$	β-Aminoborneol	MeOH	*26.1*	18	−42.47	(**398**)
$C_{11}H_{19}NO_2$	α-Isonitroso-β-methylborneol	$CHCl_3$	2.35		84.2	(**587**)
	β-Isonitroso-β-methylborneol	$CHCl_3$	2.1		67.8	
	γ-Isonitroso-β-methylborneol	$CHCl_3$	1.30		45	
$C_{11}H_{20}O$	Isobornyl methyl ether (from camphene)		0.9277$^{20}_{4}$	21	−14.82	(**1411**)
	(from camphene HCl)		0.9277$^{20}_{4}$	25	−23.4	
$C_{11}H_{20}O$	Methylborneol	EtOH			30.79	(**2231**)
$C_{12}H_{19}Cl_3O_2$	Chloral borneol	C_6H_6	15.07	15.5	30.13	(**785**)
$C_{12}H_{19}Br_3O_2$	Bromal borneol	C_6H_6	21.7	15.5	52.4	(**1430**)
$C_{12}H_{22}O$	Ethylborneol		0.9490^{0}		26.3	(**175**)
		EtOH	26.3	18	36.98	(**1281**)
$C_{13}H_{22}O$	Bornyl allyl ether		0.9221$^{21}_{4}$		−59.1	(**814**)
$C_{13}H_{22}O$	Allylborneol	EtOH	5.07	16	20.37	(**1281**)
$C_{13}H_{24}O$	Methylethylborneol	EtOH	3.04	14	39.02	(**1281**); *cf.* (**813**)
$C_{14}H_{26}O$	Isobutylborneol	EtOH			20.7	(**823**)
$C_{14}H_{26}O$	Diethylborneol	EtOH	2.32	18	51.62	(**1281**); *cf.* (**813**)
$C_{16}H_{26}O$	Diallylborneol	EtOH	2.79	18	78.77	(**1281**)
$C_{17}H_{24}O$	α-Benzylborneol		1.1325$^{18}_{4}$		26.17	(**802**)
	β-Benzylborneol				−12.00	
$C_{18}H_{22}O$	Phenylethenylborneol	C_6H_6	*10*	20	−27.37	(**1828**)
$C_{18}H_{24}O$	Dihydrophenylethenylborneol	C_6H_6			−101.7	(**1828**)
$C_{20}H_{27}NO_2$	Allylborneol phenylcarbamate	EtOH	8.25	16	19.38	(**1281**)
$C_{21}H_{31}NO_2$	Diethylborneol phenylcarbamate	EtOH	5.78		42.05	(**1281**)
$C_{24}H_{30}O$	*l*-Dibenzylborneol	EtOH	2.54	19	−15.72	(**1281**); *cf.* (**813**)
	Borneol esters and carboxylates					
$C_{10}H_{17}Cl_3OSi$	*l*-Bornyl trichlorosilicate ($C_{10}H_{17}O.SiCl_3$)		1.189	24.9	−20.09	(**1597**)
$C_{11}H_{18}O_2$	*l*-Bornyl formate ($C_{10}H_{17}O.CHO$)		1.0058	20	−40.46	(**295**)
$C_{11}H_{18}O_2$	*d*-Bornyl formate		1.009$^{22}_{4}$		48.75	(**106**)
	Isobornyl formate	EtOH	4.55		36.6	(**1440**)
$C_{11}H_{19}NOS$	Bornylxanthamide ($C_{10}H_{17}O.CS.NH_2$)	C_6H_6	6.41		18.95	(**299**)
$C_{11}H_{18}O_3$	Epiborneolcarboxylic acid (isomeride A)	AcOEt	4.65		2.36	(**238**)
	(isomeride B)	AcOEt	5.52		−4.8	
	(isomeride D)	AcOEt	0.693		77.9	



Borneol esters and carboxylates.—(Continued)

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_{12}H_{20}O_2$	*l*-Bornyl acetate	EtOH	19.6	15.5	44.97	(783)
			0.9855	20	−44.40	(295)
	Isobornyl acetate	EtOH	4.90		44.3	(1440)
$C_{13}H_{20}O_3$	*l*-Bornyl pyruvate		1.0467	19.9	−52.4	(1352)
$C_{13}H_{22}O_2$	*l*-Bornyl propionate		0.9717	20	−42.06	(295)
$C_{13}H_{22}O_2$	Isobornyl propionate	EtOH	5.25		48.8	(1440)
$C_{13}H_{22}O_3$	*l*-Bornyl *dl*-lactate		1.0370^{20}_{4}	20	−39.3	(1347)
		EtOH	5.26	20	−36.4	
$C_{14}H_{20}O_4$	*l*-Bornyl hydrogen fumarate	$CHCl_3$	6.79	12	−48.7	(1353)
		EtOH	4.05	11.5	−44.8	
$C_{14}H_{22}O_2$	Bornyl crotonate; *cf.* (1434)	EtOH	5.55		42.7	(1440)
$C_{14}H_{22}O_4$	Bornyl hydrogen succinate	EtOH	25.4	15.5	35.59	(782)
$C_{14}H_{24}O_2$	Bornyl butyrate	EtOH	5.6		−4.01	(1434)
			0.9611	20	−39.15	(295)
$C_{14}H_{24}O_2$	Isobornyl butyrate	EtOH	5.60		50.6	(1440)
	Isobornyl isobutyrate	EtOH	5.60		47.7	
$C_{14}H_{24}O_3$	*l*-Bornyl *dl*-α-hydroxybutyrate	EtOH	4.734	20	−34.5	(1347)
$C_{15}H_{26}O_2$	Isobornyl valerate	EtOH	5.95		49.8	(1440)
	l-Bornyl valerate		0.9533	20	−37.08	(295)
$C_{15}H_{26}O_3$	*l*-Bornyl *dl*-ethoxypropionate	EtOH	0.9858	20	−33.2	(1347)
		EtOH	4.93	20	−30.7	
$C_{16}H_{30}O_2$	*l*-Bornyl hexoate		0.9343	20	−31.45	(295)
$C_{17}H_{22}O_2$	Bornyl benzoate	EtOH	25.8	15.5	43.92	(783)
$C_{17}H_{23}NO_2$	*d*-Bornylphenylcarbamate ($C_{10}H_{17}O.CO.NH.C_6H_5$)	PhMe	5.46	15.5	34.22	(784)
$C_{17}H_{24}O_3S$	Bornyl toluene-*p*-sulfonate ($C_{10}H_{17}O.SO_2.C_6H_4.CH_3$)	EtOH	2.207	20	15.46	(451)
		C_6H_6	2	20	15.46	
$C_{18}H_{22}O_4$	*d*-Isobornyl hydrogen phthalate	$CHCl_3$	5.18		76.88	(1629)
$C_{18}H_{22}O_4$	*d*-Bornyl hydrogen phthalate	EtOH	30.2	15.5	58.38	(782)
		EtOH	5.07		56.7	(1629)
$C_{18}H_{24}O_3$	*l*-Bornyl *d*-mandelate	EtOH	4.44	19	23.2	(1348)
	l-Bornyl *l*-mandelate	EtOH	4.64	20.5	−84.2	
	l-Bornyl *dl*-mandelate	EtOH	6.688	20	−30.4	(1347)
$C_{19}H_{22}O_2$	Bornyl phenylpropiolate	$CHCl_3$	10	21	31.05	(900)
		$CHCl_3$	2.5	22	31.40	
		Me_2CO	10	20	31.70	
		Me_2CO	2.5	22	30.20	
$C_{19}H_{24}O_2$	Bornyl cinnamate	$CHCl_3$	10	21	29.05	(900)
		$CHCl_3$	2.5	21	28.40	
		Me_2CO	10	20	29.10	
		Me_2CO	2.5	22	27.60	
		EtOH	7.1		35.5	(1440)
$C_{19}H_{26}O_2$	Bornyl β-phenylpropionate	$CHCl_3$	10	20	30.25	(900)
		$CHCl_3$	2.5	20	29.20	
		Me_2CO	10	20	29.00	
		Me_2CO	2.5	22	29.20	
$C_{20}H_{28}O_3$	*l*-Bornyl *dl*-phenylethoxyacetate		1.0407	20	−27.5	(1347)
		EtOH	4.239	20	−29.1	
$C_{20}H_{34}Cl_2O_2Si$	Di-*l*-bornyl dichlorosilicate ($SiCl_2(OC_{10}H_{17})_2$)		1.0926	25.4	−30.3	(1597)
$C_{24}H_{36}O_4$	Di-*l*-bornyl fumarate	EtOH	1.57		−45.2	(1434)
		$CHCl_3$	5.28	10.5	−62	(1353)
		EtOH	1.54	9.5	−57.6	
$C_{24}H_{38}O_4$	Dibornyl succinate	EtOH	1.57		−38.9	(1434)
		EtOH	39	15.5	42.05	(782)
$C_{24}H_{38}O_6$	Di-*l*-bornyl *dl*-tartrate	$CHCl_3$	3.96	10.5	−38.5	(1353)
$C_{28}H_{38}O_4$	Dibornyl phthalate	EtOH	43.8	15.5	79.54	(782)
$C_{28}H_{43}NO_4$	*l*-Menthylamine *d*-bornyl phthalate	EtOH	5.0		17.2	(1629)
$C_{28}H_{50}O_2$	Bornyl oleate	EtOH	10.45		20.3	(1440)
$C_{28}H_{52}O_2$	Bornyl stearate	C_6H_6	10.5		19.9	(1440)
$C_{30}H_{51}ClO_3Si$	Tri-*l*-bornyl chlorosilicate ($SiCl(OC_{10}H_{17})_3$)	PhMe	16.5	20	−36.7	(1597)
$C_{37}H_{56}N_2O_4S$	*d*-Bornyl-*l*-bornyl benzamidine *d*-camphorsulfonate	EtOH	4.1412	16	16.2	(340)

Borneol esters and carboxylates.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{40}H_{68}O_4Si$	Tetra-*l*-bornyl silicate ($Si(OC_{10}H_{17})_4$)	PhMe	16.8	20	−42.88	**(1597)**
	GLYCOLS					
$C_{12}H_{22}O_2$	Campholethanol*	EtOH	5.0	15	19.95	**(1553)**
$C_{20}H_{34}O_2$	Camphorpinacol (also derivatives)	C_6H_6	*25.47*	18	44.17	**(102)**
$C_{20}H_{34}O_2$	*d*-Fenchonepinacol	AcOEt	*16.8*	15	45.00	**(2122)**
		C_6H_6	*17.24*	18	32.08	
$C_{25}H_{32}N_2O_4$	Phenylurethane homocamphoric glycol†	EtOH	5.7	21	31.48	**(1553)**
	CARBOXYLIC ACIDS					
$C_{11}H_{18}O_3$	α-Borneolcarboxylic acid	MeOH	12.44	22	−34.8	**(2131)**
$C_{14}H_{22}O_5$	1-Methyl acid campholethanoyl-1-methanoate‡	EtOH	2.7	20	49.37	**(1553)**
	AMINES					
	MONOAMINES					
	Fenchylamine, thujylamine and derivatives					
$C_{10}H_{17}NO$	Fenchelylcarbimide		0.9210	19	3.04	**(2122)**
$C_{10}H_{19}N$	*l*-Fenchylamine; *cf.* (**145, 2110, 2126**)	EtOH	*2.63*	19	−24.63	**(2108)**
$C_{11}H_{19}NOS$	*l*-Fenchylxanthamide ($C_{10}H_{17}O.CS.NH_2$)	C_6H_6	10.40		−78.51	**(299)**
$C_{10}H_{20}ClN$	Fenchelylamine hydrochloride	H_2O	*18.52*	20	2.95	**(2122)**
$C_{12}H_{23}N$	Dimethylthujylamine		0.8606^{20}_{4}		141.76	**(297)**
$C_{13}H_{28}INO$	Trimethylthujylammonium iodide	$CHCl_3$	3.979		42.61	**(297)**
	Bornylamine with alkyl and alkylidene derivatives					
$C_{10}H_{19}N$	Bornylamine	C_6H_6			57.1	**(575, 576)**
		EtOH			46.2	
$C_{10}H_{20}IN$	Bornylamine hydroiodide	EtOH?			16.0	
$C_{11}H_{21}N$	Methylbornylamine				96.8	
		C_6H_6	2.069	19	95.9	
		EtOH	2.026	23	81.0	
$C_{11}H_{22}ClN$	Methylbornylamine hydrochloride	EtOH	2.4		31.0	
$C_{11}H_{22}IN$	Methylbornylamine hydroiodide	EtOH	1.0		26.6	
$C_{12}H_{23}N$	Dimethylbornylamine			16	62.5	
		C_6H_6	1.558	10	59.6	
		EtOH	2.606	10	48.7	
$C_{12}H_{23}N$	Ethylbornylamine			21	93.0	
		C_6H_6	2.031	15	90.3	
		EtOH	2.673	15	75.4	
$C_{12}H_{24}ClN$	Dimethylbornylamine hydrochloride	EtOH			37.2	
$C_{12}H_{24}ClN$	Ethylbornylamine hydrochloride	H_2O	1.3		35.6	
$C_{12}H_{24}IN$	Ethylbornylamine hydroiodide	EtOH	2.0		26.6	
$C_{13}H_{25}N$	Propylbornylamine			18	89.0	
		C_6H_6	2.420	15	87.1	
		EtOH	2.084	16	72.0	
$C_{13}H_{25}N$	Isopropylbornylamine			14	84.0	
		C_6H_6	2.003	16	81.1	
		EtOH	2.014	16	63.3	
$C_{13}H_{26}ClN$	Propylbornylamine hydrochloride	EtOH	2.0		34.4	
$C_{13}H_{26}IN$	Propylbornylamine hydroiodide	EtOH	1.7		25.0	
$C_{13}H_{26}IN$	Trimethylbornylammonium iodide	EtOH	2.9		−3.9	
$C_{14}H_{27}N$	Diethylbornylamine	C_6H_6	1.596	15	62.6	
		EtOH	1.981	22	50.5	
$C_{14}H_{27}N$	Butylbornylamine			15	81.7	
		C_6H_6	1.947	16	80.3	
		EtOH	1.993	16	64.8	
$C_{14}H_{28}ClN$	Butylbornylamine hydrochloride	EtOH	2.0		32.7	
$C_{14}H_{28}IN$	Butylbornylamine hydroiodide	EtOH	2.0		23.8	
$C_{14}H_{28}IN$	Dimethylethylbornylammonium iodide	EtOH	2.0	18	−3.3	
$C_{15}H_{30}IN$	Dimethylpropylbornylammonium iodide	EtOH	2.03	16	−4.1	
$C_{16}H_{32}IN$	Dimethylbutylbornylammonium iodide	EtOH	2.0		−3.1	
$C_{17}H_{22}N_2O_2$	*o*-Nitrobenzylidenebornylamine	C_6H_6	2.004	23	41.6	
		EtOH	2.032	23	8.6	
	p-Nitrobenzylidenebornylamine	C_6H_6	1.628	15	23.0	
		EtOH	1.795		51.5	

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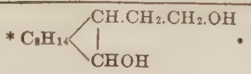
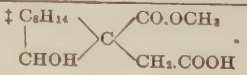
* 

$C_8H_{14}\left\langle\begin{array}{l}CH.CH_2.CH_2.OH\\ |\\ CHOH\end{array}\right.$.

† $C_6H_5.NH.CO.O.CH_2.C_8H_{14}.CH_2.CH_2.O.CO.NH.C_6H_5$.

‡ 

$\begin{array}{l}C_8H_{14}\\ |\\ CHOH\end{array}\rangle C\left\langle\begin{array}{l}CO.OCH_3\\ CH_2.COOH\end{array}\right.$.

Bornylamine with alkyl and alkylidene derivatives.—(Continued)

Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{17}H_{23}NO$	Benzoylbornylamine	EtOH			−21.8	(635)
$C_{17}H_{23}N$	Benzylidenebornylamine	C_6H_6	2.005	20	27.4	(575, 576)
		EtOH	2.051	19	62.6	
$C_{17}H_{23}NO$	*o*-Hydroxybenzylidenebornylamine	EtOH	1.951	23	112.3	
	p-Hydroxybenzylidenebornylamine	EtOH	2.022		107.1	
$C_{17}H_{24}N_2O_2$	*o*-Nitrobenzylbornylamine	C_6H_6	2.033	15	74.0	
		EtOH	2.027	15	61.2	
$C_{17}H_{24}N_2O_2$	*p*-Nitrobenzylbornylamine	C_6H_6	2.033	15	77.9	
		EtOH	2.015	22	66.6	
$C_{17}H_{25}ClN_2O_2$	*o*-Nitrobenzylbornylamine hydrochloride		2.0		113.2	
$C_{17}H_{25}ClN_2O_2$	*p*-Nitrobenzylbornylamine hydrochloride	EtOH	2.0		20.3	
$C_{17}H_{25}N$	Benzylbornylamine			17	82.2	
		C_6H_6	2.010	14	84.1	
		EtOH	2.228	20	75.7	
$C_{17}H_{26}ClN$	Benzylbornylamine hydrochloride	EtOH	1.7		35.8	
$C_{18}H_{25}NO$	Benzoylmethylbornylamine	EtOH	1.772	24	−65.5	
$C_{19}H_{27}NO$	Benzoylethylbornylamine	EtOH	2.761	21	−65.2	
$C_{20}H_{29}NO$	Benzoylpropylbornylamine	EtOH	1.961	14	−60.3	
$C_{20}H_{34}BrNO_4S$	*d*-Bornylamine *d*-α-bromocamphor-π-sulfonate	EtOH	0.604		81.0	(1676)
		H_2O	0.616		67.3	
	Acyl derivatives of bornylamine					
$C_{11}H_{19}NO$	Formobornylamide	EtOH	*5.3*	20	−43.17	(635)
		MeOH	*5.0*	20	−40.88	
		MeOH	*10.0*	20	41.01	
		AcOH	*5.6*	20	−13.80	
		AcOH	*9.7*	20	−15.30	
		Py	*5.0*	20	−16.96	
		Py	*10.0*	20	−18.60	
$C_{12}H_{21}NO$	Acetobornylamide	EtOH	*4.9*	20	−43.48	(635)
		MeOH	*5.0*	20	−41.93	
		MeOH	*10.0*	20	−42.10	
		AcOH	*5.0*	20	−34.80	
		AcOH	*10.0*	20	−36.14	
		Py	*4.9*	20	−11.97	
		Py	*10.0*	20	−15.14	
$C_{13}H_{23}NO$	Propionobornylamide	EtOH	*5.0*	20	−40.79	
		MeOH	*5.0*	20	−38.68	
		MeOH	*10.0*	20	−39.48	
		AcOH	*5.0*	20	−37.19	
		AcOH	*10.0*	20	−37.54	
		Py	*5.0*	20	−14.64	
		Py	*10.0*	20	−16.38	
$C_{14}H_{25}NO$	*n*-Butyrobornylamide	EtOH	*5.0*	20	−37.73	(635)
		EtOH			−21.8	(575, 576)
		MeOH	*5.0*	20	35.73	(635)
		MeOH	*10.0*	20	35.86	
		AcOH	*5.0*	20	34.89	
		AcOH	*10.0*	20	35.29	
		Py	*4.9*	20	−12.57	
		Py	*10.0*	20	−15.06	
$C_{17}H_{23}NO$	Benzobornylamide	EtOH	*5.0*	20	−22.93	(635)
		EtOH	*10.0*	20	−24.37	
		MeOH	*5.0*	20	22.35	
		MeOH	*10.0*	20	23.30	
		AcOH	*5.0*	20	10.17	
		AcOH	*10.0*	20	11.65	
		Py	*5.0*	20	25.94	
		Py	*10.0*	20	22.98	
$C_{17}H_{22}N_2O_3$	*o*-Nitrobenzobornylamide	EtOH	*5.0*		−22.39	(635)
		MeOH	*5.1*	20	30.32	
		AcOH	*3.9*	20	13.54	
		Py	*5.0*	20	−5.88	
		Py	*10.0*	20	−7.67	

Acyl derivatives of bornylamine.—(Continued)

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_{17}H_{22}N_2O_3$	*m*-Nitrobenzobornylamide	EtOH	*2.6*	20	−27.9	(635)
		MeOH	*1.9*	20	24.62	
		AcOH	*3.9*	20	12.16	
		Py	*5.00*	20	27.22	
		Py	*9.99*	20	22.16	
	p-Nitrobenzobornylamide	EtOH	*4.28*	20	−16.75	
		MeOH	*5.00*	20	−13.44	
		AcOH	*3.83*	20	−7.28	
		Py	*4.7*	20	26.41	
		Py	*9.9*	20	22.80	
$C_{18}H_{25}NO$	*o*-Toluobornylamide	EtOH	*2.5*	20	−18.54	(635)
		MeOH	*2.0*	20	−17.02	
		MeOH	*4.0*	20	−17.01	
		AcOH	*5.0*	20	−10.38	
		AcOH	*10.0*	20	−11.34	
		Py	*5.0*	20	11.21	
		Py	*10.0*	20	10.24	
	m-Toluobornylamide	EtOH	*2.5*	20	−21.31	
		EtOH	*5.0*	20	−22.40	
		MeOH	*2.0*	20	−20.37	
		MeOH	*4.0*	20	−21.60	
		AcOH	*5.0*	20	−8.15	
		AcOH	*10.0*	20	−8.98	
		Py	*5.0*	20	26.90	
		Py	*10.0*	20	23.05	
	p-Toluobornylamide	EtOH	*2.5*	20	−13.37	
		EtOH	*5.0*	20	−14.55	
		MeOH	*2.0*	20	−12.18	
		MeOH	*4.0*	20	−12.51	
		AcOH	*1.0*	20	±0.0	
		AcOH	*5.0*	20	−0.49	
		AcOH	*10.0*	20	−1.51	
		Py	*5.0*	20	30.60	
		Py	*7.8*	20	29.03	
		Py	*10.0*	20	27.39	
$C_{21}H_{37}NO_2$	*l*-Bornyl *l*-menthylcarbamate	EtOH	3.4		−71.04	(1629)
	dl-Isobornyl *l*-menthylcarbamate*	EtOH	5		−55.8	
	d-Isobornyl *l*-menthylcarbamate	EtOH	2.67		1.41	
	l-Isobornyl *l*-menthylcarbamate	EtOH	2.64		−112.0	

Bornylcarbimide, carbamide and other derivatives of dibasic acids

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_{11}H_{17}NO$	Bornylcarbimide ($C_{10}H_{17}.N:CO$)	$CHCl_3$	3.76		46.5	(590)
		C_6H_6	4.5		49.14	(1514); *cf.* (590)
$C_{11}H_{20}N_2O$	Bornylcarbamide ($C_{10}H_{17}.NH.CO.NH_2$)	$CHCl_3$	2.15		18.2	(590)
$C_{12}H_{20}N_2O_2$	Bornyloxamide ($C_{10}H_{17}.NH.CO.CO.NH_2$)	EtOH	*2*		−24.1	(598)
$C_{13}H_{23}NO_2$	Ethyl bornylcarbamate ($C_{10}H_{17}.NH.CO.OC_2H_5$)	$CHCl_3$	2.25		6.43	(1514)
		C_6H_6	2.19		4.79	
	Ethyl neobornylcarbamate	C_6H_6	2.04		−9.63	
$C_{16}H_{28}N_2O$	*s*-Bornylpiperidylcarbamide ($C_{10}H_{17}.NH.CO.N.C_5H_{10}$)	EtOH	1.35		40.0	(590)
$C_{21}H_{34}N_2O_2$	*s*-Camphorylbornylcarbamide ($C_{10}H_{15}O.NH.CO.NH.C_{10}H_{17}$)	$CHCl_3$	1.2		28.6	(591)
$C_{21}H_{36}N_2O$	Dibornylcarbamide ($CO.(NH.C_{10}H_{17})_2$)	$CHCl_3$	1.09		32.12	(1514)
$C_{22}H_{36}N_2O_2$	Dibornyloxamide (($CO.NH.C_{10}H_{17})_2$)	EtOH	*2.0*		−29.6	(598)
$C_{39}H_{60}NO_4S$	Ethyl-*d*-bornyl-*l*-bornylbenzamidine *d*-camphorsulfonate	EtOH	3.995	16	16.1	(1597)

CLASS III. COMPOUNDS CONTAINING NO ASYMMETRIC CARBON ATOM OR CONTAINING AN ASYMMETRIC OR DISSYMMETRIC ATOM OF SOME OTHER ELEMENT†

Centro-Asymmetric Carbon Compounds

Cyclohexylideneacetic acid

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_{32}H_{40}N_2O_6$	Brucine *l*-1-methylcyclohexylidene-4-acetate	EtOH	0.7607		−58.2	(1601.5)
		EtOH (abs.)	0.775		−58.1	(1601)

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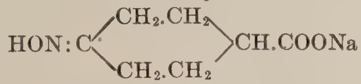
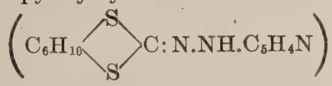
* $C_{10}H_{17}O.CO.NH.C_{10}H_{19}$.

† For $C_9H_{33}CoN_6O_3$, Cobalt tri-*l*-propylenediamine hydroxide iodide, *see* p. 365.

Cyclohexylideneacetic acid.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{32}H_{40}N_2O_6$	Brucine *l*-1-methylcyclohexylidene-4-acetate.	EtOH (abs.)	1.986		−49.8	
	(*Continued*)	EtOH (abs.)	2.833		−46.9	
		MeOH	0.839		−78.6	
		H_2O	0.727		−38.6	
	Brucine *d*-1-methylcyclohexylidene-4-acetate	EtOH	0.7431		11.5	(1601.5)
		EtOH (abs.)	1.171		−11.5	(1601)
		EtOH (abs.)	2.002		−3.9	
		EtOH (abs.)	2.767		−1.4	
		EtOH (abs.)	5.189		2.4	
		MeOH	0.700		−22.1	
		H_2O	0.700		−2.9	
	Nitrogen derivatives (*oximes, etc.*)					
$C_7H_{10}NO_3Na$	Sodium *d*-oximinocyclohexane-4-carboxylate	H_2O	2.98		41.6	(1424)
						
$C_{12}H_{15}N_3S_2$	*d*-Cyclohexylene dithiocarbonate-2-pyridylhydrazone					
	..........	CS_2	1.032	17	46.3	(1427)
		EtOH	0.308	17	46	
	l-Cyclohexylene dithiocarbonate 2-pyridylhydrazone....................	EtOH	0.338	18	−83	
$C_9H_{13}NO$	*d*-Methylethylaniline oxide ($C_6H_5.N.CH_3.C_2H_5O$)...................	H_2O	*1.5*		+16.1	(1411.5)
		C_6H_6	*1.8*		+6.1	
	Derivatives of diphenic acid					
$C_{14}H_6N_3O_{10}Na$	Sodium *d*-4, 6, 4′-trinitrodiphenate.........	H_2O	*1.5*	16	156.8	(293)
$C_{14}H_6O_4Cl_2Na_2$	Sodium *l*-6, 6′-dichlorodiphenate...........	H_2O	*0.69*	15	−20.18	(292)
	Sodium *d*-6, 6′-dichlorodiphenate...........	H_2O	*1.01*	15	21.43	
	Optically Active Quinquevalent Nitrogen Compounds (730, 1969)					
$C_{13}H_{15}NO.3H_2O$	*d*-Methylethyl-β-naphthylamine oxide ($C_{10}H_7.N(CH_3)(C_2H_5)O$)................	H_2O	2.02		+14.8	(1411.5)
	l-Base..................................				−15.4	
$C_{14}H_{21}BrIN$	*p*-Bromophenylmethyl-*n*-butylallyl-ammonium iodide.....................	EtOH	*1.13*		27.97	(437)
		$CHCl_3$	*4.78*		44.36	
$C_{14}H_{22}IN$	*d*-Phenylmethyl-*n*-butylallylammonium iodide ($C_6H_5.N(CH_3)(C_4H_9)(C_3H_5)I$).......	EtOH	1.28	15	31.78*	(437)
		$CHCl_3$	*0.70*	15	34.17*	
$C_{14}H_{22}IN$	Phenylmethylallylisobutylammonium iodide	EtOH	0.77	17	−19.08	(2013)
		$CHCl_3$	0.574	17	0*	
$C_{15}H_{23}BrIN$	*d*-Bromophenylmethylisoamylallyl-ammonium iodide.....................	EtOH			26.2	(1009)
		$CHCl_3$	*0.73*		39.9	
$C_{15}H_{24}BrN$	*l*-1-Benzyl-1-ethyl-2-pipecolinium bromide ($CH_3.C_5H_9N(C_2H_5)(CH_2.C_6H_5)Br$).........	EtOH	*10*		20	(1887)
$C_{15}H_{24}IN$	*l*-1-Benzyl-1-ethyl-2-pipecolinium iodide.....	EtOH	*10*		−52.5	(1887)
$C_{15}H_{24}IN$	*d*-α-Phenylmethylallyl-*l*-amylammonium iodide	EtOH	3.436		14.3	(1007)
		$CHCl_3$	3.444		21.78*	(1007)
					3.1	(1007)
$C_{16}H_{20}IN$	*d*-Phenylbenzylmethylethylammonium iodide..................................	EtOH	2.25		7.8	(1005)
	l-Phenylbenzylmethylethylammonium iodide	EtOH	2.22		−8.5	(1006)
$C_{17}H_{19}BrIN$	*p*-Bromophenylbenzylmethylallylammonium iodide..................................	EtOH	*0.97*	14	−55	(437)
		$CHCl_3$	*0.85*	15	−72*	
$C_{17}H_{20}BrN$	*d*-Benzylphenylallylmethylammonium bromide...............................	$CHCl_3$	0.495	16.5	64.1	(1668)
		EtOH	0.97		68.6	(1673)
	l-Benzylphenylallylmethylammonium bromide................................	EtOH	1.49		67.3	

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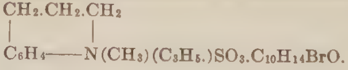
* Mutarotation.

Optically Active Quinquevalent Nitrogen Compounds.—(*Continued*)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{17}H_{20}IN$	*d*-Benzylphenylallylmethylammonium iodide	$CHCl_3$	1.05	17	55.4	(1668)
		$CHCl_3$	1.11	14	56.7	(835)
		50% Me_2CO + MeOH	0.97		52.5	(1673)
	l-Benzylphenylallylmethylammonium iodide	50% Me_2CO + 50% MeOH	2.07		−51.4	
$C_{17}H_{21}NO$	α-Phenylbenzylmethylallylammonium hydroxide	EtOH aq.	0.794	18	75.5	(2138)
$C_{17}H_{22}ClN$	*l*-Phenylbenzylmethylpropylammonium chloride	$CHCl_3$	0.46		−143.8	(2154)
$C_{17}H_{22}IN$	*l*-Phenylbenzylmethylpropylammonium iodide	EtOH	0.466		−96.47	(2146)
		$CHCl_3$	0.515		−102	
		EtOH	*0.71*	17	−116.2	(2013)
		$CHCl_3$	*0.52*		−139	
$C_{17}H_{22}N_2O_3$	*d*-Phenylbenzylmethylpropylammonium nitrate	$CHCl_3$	2.8		14	(2139)
$C_{17}H_{28}IN$	α-Benzylethylconiinium iodide ($C_3H_7.C_5H_9N(C_2H_5)(CH_2C_6H_5)I$)	MeOH	8	20	21.2	(1884)
	β-Benzylethylconiinium iodide	MeOH	8	20	31.2	
$C_{18}H_{22}IN$	*p*-Tolylbenzylmethylallylammonium iodide	EtOH	*0.4*		−66.7	(438)
		$CHCl_3$	*0.34*		−66.9	
$C_{18}H_{22}INO$	*p*-Methoxyphenylbenzylmethylallylammonium iodide	$CHCl_3$	4	20	6.39	(693)
$C_{18}H_{23}BrIN$	*l*-*p*-Bromophenylbenzylmethyl-*n*-butylammonium iodide	EtOH	*0.94*	15	−77.13	(437)
		$CHCl_3$	*0.64*		7.100*	
$C_{18}H_{24}IN$	*l*-Phenylbenzylmethylbutylammonium iodide	EtOH	0.72	20	−83.66	(694)
		$CHCl_3$	0.77	20	−90.61	
$C_{18}H_{24}IN$	*l*-Phenylbenzylmethylisobutylammonium iodide	EtOH	*0.52*		−99.2	(2147); *cf.*
		$CHCl_3$	*0.36*		−98.5*	(2013)
$C_{19}H_{24}INO$	*l*-*p*-Ethoxyphenylbenzylmethylallylammonium iodide	$CHCl_3$	5.23	20	−1.63	(2147.5)
$C_{19}H_{26}IN$	α-Phenylbenzylmethyl-*l*-amylammonium iodide	EtOH	*1.21*		59	(1007)
	β-Phenylbenzylmethyl-*l*-amylammonium iodide	$CHCl_3$	*0.864*		65*	(1007)
		EtOH	*1.831*		−15.8	
		$CHCl_3$	*1.22*		−18.8*	
$C_{19}H_{26}IN$	*l*-Phenylbenzylmethylisoamylammonium iodide	EtOH	*1.33*		−87	(201.3)
		$CHCl_3$	*0.72*		−100*	
$C_{20}H_{34}IN$	α-Benzylisoamylconiinium iodide	$CHCl_3$	7.5	20	26.6	(1884)
	β-Benzylisoamylconiinium iodide	$CHCl_3$	7.5	20	33.3	
$C_{23}H_{32}BrNO_4S$	*l*-Allylkairolinium *d*-bromocamphorsulfonate†	H_2O	*0.94*		39.1	(258)
	d-Allylkairolinium *d*-bromocamphorsulfonate	H_2O	*0.9608*		68.6	
$C_{24}H_{38}INO_2$	*N*-Isopropyltetrahydroisoquinolinium-*l*-menthyl acetate iodide‡ (*a*) stable form	EtOH	0.698	20	−40.12	(2151)
	(*b*) unstable form	EtOH	0.478	20	−12.54	
$C_{24}H_{38}INO_2$	*N*-*n*-Propyltetrahydroisoquinolinium-*l*-menthyl acetate iodide	EtOH	1.02		−22.6	(2150)
		$CHCl_3$	1.16		−23.2	
		$CHCl_3$	0.79		−31.7	
		EtOH	0.99		−31.86	
$C_{25}H_{36}I_2N_2$	*p*-Methylene-bisphenylenebis-(methylethylallylammonium iodide) ($CH_2(C_6H_4.NI(CH_3)(C_2H_5)(C_3H_5))_2$)	60% EtOH	0.99	20	−11.11	(692)

* Mutarotation.

†


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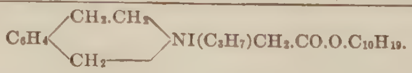

Optically Active Quinquevalent Nitrogen Compounds.—(*Continued*)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{25}H_{40}INO_2$	*N*-Butyltetrahydroisoquinolinium *l*-menthyl acetate iodide (*a*) stable form	EtOH	1.0	20	−29.2	(2151)
	(*b*) unstable form	EtOH	1.0	20	−18.1	
$C_{26}H_{42}INO_2$	*N*-Isoamyltetrahydroisoquinolinium *l*-menthyl acetate iodide (*a*) stable form	EtOH	1.0	20	6.4	(2151)
	(*b*) unstable form	EtOH	1.0	20	−26.1	
$C_{29}H_{38}BrNO_5S$	*l*-*p*-Ethoxyphenylbenzylmethylallylammonium *d*-bromocamphorsulfonate	H_2O	2.27	20	7.95	(2147.5)
$C_{32}H_{49}IN_2O_2$	Ethylene-di-*d*-benzylconiinium iodide (α-salt)	MeOH	1.008		40.42	(1673); *cf.*
	(β-salt)	MeOH	0.420		15.42	(1884)
	Substances Probably, or Certainly, Containing Optically Active Phosphorus Atoms					
$C_9H_{13}OP$	α-Methylethylphenylphosphine oxide $(C_6H_5).P.(CH_3)(C_2H_5)O)$	H_2O	1.34		39	(1412)
		C_6H_6	0.887		57	
$C_{23}H_{32}NO_3P$	Phenyl-*p*-tolylphosphoric *l*-menthylamide* (α-isomeride)	98% MeOH	1.3		−32.3	(1311.5)
	(β-isomeride)	98% MeOH	1.107		−37.9	
$C_{26}H_{32}NO_3P$	α-Phenyl β-naphthyl phosphoric *l*-menthylamide†	MeOH	2.336		−37.2	(1074)
	β-Phenyl β-naphthyl phosphoric *l*-menthylamide	MeOH	1.521		−29.1	
$C_{26}H_{34}NO_4P$	*l*-Menthylamine phenyl β-naphthyl phosphate‡	MeOH	1.4980		−15.5	(1074)
$C_{36}H_{37}N_2O_6P$	Quinine phenyl β-naphthyl phosphate	MeOH	0.6492		−108.6	(1074)
		MeOH	0.7612		−108.4	
	Compounds Containing Optically Active Sulfur or Selenium					
$C_{18}H_{22}Cl_6O_4PtSe_2$	*d*-Phenylmethylselenetine chloroplatinate§	Me_2CO	2.15		6.34	(1669)
$C_{10}H_{22}Cl_6O_4PtS_2$	*d*-Methylethylthetine chloroplatinate	H_2O	1.33		4.6	(1674)
$C_{17}H_{17}N_3O_8S$	*l*-Methylethylphenacylsulfine picrate	Me_2CO	2.07		−9.2	(1967)
	d-Methylethylphenacylsulfine picrate	Me_2CO	1.96		8.1	
$C_{22}H_{30}Cl_6O_2PtS_2$	*l*-Methylethylphenacylthetine chloroplatinate	HCl (concd.)	0.42		−7.7	(1669)
	Compounds Containing Optically Active Silicon					
$C_{23}H_{36}O_7S_2Si_2Na_2$	*d*-Sulfobenzylethylpropylsilicyl oxide, sodium salt	H_2O	6.85		5.2	(1072)
$C_{24}H_{38}O_7S_2Si_2Na_2$	*d*-Sulfobenzylethylisobutylsilicyl oxide, sodium salt‖	H_2O	3.32		10.4	(1311)
	Salts of dibenzylpropylethylsilicanemonosulfonic acid, $C_6H_5.CH_2.Si.C_2H_5.C_3H_7.CH_2.C_6H_4.SO_2.OH$					
$C_{19}H_{25}O_3SSiNa$	Sodium *l*-salt	MeOH			−0.87	(282)
$C_{29}H_{47}NO_3SSi$	*l*-Menthylamine *dl*-salt	MeOH	2.8		−13.4	
$C_{29}H_{47}NO_3SSi$	*l*-Menthylamine *l*-salt	MeOH	13.6		−13.8	
$C_{36}H_{45}NO_6SSi$	Morphine *dl*-salt	MeOH	1.68		−52.2	
$C_{36}H_{45}NO_6SSi$	Morphine *l*-salt	MeOH	1.66		−56.0	
$C_{38}H_{48}N_2O_4SSi$	Cinchonidine *dl*-salt	MeOH	2.23		−62.1	
$C_{38}H_{48}N_2O_4SSi$	Cinchonidine *l*-salt	MeOH	2.1		−66.3	
$C_{39}H_{50}N_2O_5SSi$	Quinine *dl*-salt	MeOH	1.612		−111.3	
$C_{39}H_{50}N_2O_5SSi$	Quinine *l*-salt	MeOH	2.13		−109.5	
$C_{40}H_{48}N_2O_5SSi$	Strychnine *dl*-salt	MeOH	3.0		−8.3	
$C_{40}H_{48}N_2O_5SSi$	Strychnine *l*-salt	MeOH	3.5		−11.1	
	CLASS IV. SUBSTANCES OF UNKNOWN, DOUBTFUL OR COMPLEX STRUCTURE					
	Hydrocarbons and Their Simple Derivatives					
$C_{15}H_{24}$ or $C_{15}H_{22}$	Calamene		0.9324^{23}_{23}	26	−1.131	(2016)
			0.9324^{20}_{19}	20	6	(1939)
			0.9224^{20}_{19}	20	5	(1939)
$C_{15}H_{24}$	Cadinene		0.9224^{15}	20	48.11	(748)
		$CHCl_3$	*13.05*	9.5	−98.56	
$C_{15}H_{24}$	Cedrene (from pseudocedrol)		0.9338	20	−60	(1929)
$C_{15}H_{24}$	Cyclosesquicitronellene		0.8892^{20}		63	(1940)
$C_{15}H_{24}$	Cypressene		0.9647^{18}	20	6.53	(1531)
$C_{15}H_{24}$	Eudesmene		0.9232	20	51	(1942)
			0.9964	20	54.10	(1935)

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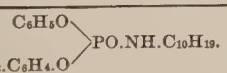
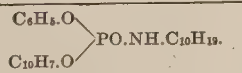
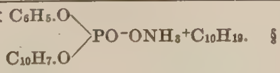
*

$$\left.\begin{array}{r}C_6H_5O\\CH_3.C_6H_4.O\end{array}\right>PO.NH.C_{10}H_{19}.$$

†

$$\left.\begin{array}{r}C_6H_5.O\\C_{10}H_7.O\end{array}\right>PO.NH.C_{10}H_{19}.$$

‡

$$\left.\begin{array}{r}C_6H_5.O\\C_{10}H_7.O\end{array}\right>PO^-ONH_3{}^+C_{10}H_{19}.$$

§ $(C_6H_5.Se(CH_3).CH_2.COOH)_2PtCl_6$.

‖ $O(Si(C_2H_5)(C_3H_7).CH_2.C_6H_4.SO_2.OH)_2$, sodium salt.

Hydrocarbons and Their Simple Derivatives.—(*Continued*)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{15}H_{24}$	Guajene		0.8954	25	−66.11	(708)
$C_{15}H_{24}$	β-Gurjunene		0.9329	20	20.4	(1941)
$C_{15}H_{24}$	α-Santalene		0.9132^{15}		−3.07	(1872)
	β-Santalene		0.894^{20}		−41.0	
$C_{15}H_{24}$	Sesquicamphene		0.9015	20	3	(1937)
$C_{15}H_{24}$	Sesquicitronellene		0.8489^{20}		0.71	
$C_{15}H_{24}N_2O_4$	Caryophyllene nitrosate	C_6H_6	*2.09*	18	56.91	(384)
$C_{15}H_{26}$	Dihydroeudesmene		0.9067	20	−7	(1942)
$C_{15}H_{26}$	Dihydroguajene		0.9089^{0}_{4}	18.5	−26.65	(708)
$C_{15}H_{26}$	Dihydro-β-gurjunene		0.9239	20	−40.1	(1941)
$C_{15}H_{26}$	Dihydrosesquicitronellene		0.8316		0	(1940)
		$CHCl_3$		20	8.91	(748)
		AcOEt		20	25.67	
$C_{15}H_{28}$	Tetrahydrocalamene		0.8951^{20}_{19}	20	0	(1939)
$C_{15}H_{28}$	Tetrahydrocaryophyllene		0.8712	20	3	(1930)
$C_{15}H_{28}$	Tetrahydroeudesmene		0.8893	20	10.20	(1935)
$C_{15}H_{28}$	Tetrahydroguajene		0.8806	20	10.60	(1935)
$C_{15}H_{28}$	Tetrahydrosantalene		0.8655	20	5.60	(1935)
$C_{15}H_{28}$	Hydrocarbon from reduction of santalol		0.8550	20	2.80	(1935)
$C_{15}H_{32}$	Octahydrosesquicitronellene		0.7789^{20}		0	(1940)
$C_{27}H_{46}$	Cholestene	$CHCl_3$	3.50		−56.27	(1402)
$C_{27}H_{46}$	ψ-Cholestene	$CHCl_3$?	3.18	23	64.86	(1403)
$C_{27}H_{46}$	Neocholestene	EtOH?	3.02	20	64.07	(1404)
$C_{27}H_{46}Br_2$	α-Cholestene dibromide	$CHCl_3$	3.05		48.9	(1402)
	β-Cholestene dibromide	$CHCl_3$	3.02		39.4	
$C_{27}H_{46}Br_2$	ψ-Cholestene dibromide	$CHCl_3$	3.19	20	83.4*	(1403)
		C_6H_6	3.21		46.9*	
$C_{27}H_{46}Br_2$	Neocholestene dibromide	EtOH?	3.10	23	75.27	(1404)
$C_{27}H_{46}Cl_2$	Cholestene dichloride	$CHCl_3$	3.20		−28.7	(1402)
$C_{27}H_{47}Cl$	Chlorocholestane	$CHCl_3$	3.138	20	29.49	(1404)
		C_6H_6	3.035	22	24.22	
$C_{27}H_{47}Cl$	Cholestene hydrochloride	$CHCl_3$	3.21		21.8	(1402)
$C_{27}H_{48}$	Cholestane	$CHCl_3$	3.03	21	24.42	(1404)
	ψ-Cholestane	$CHCl_3$	3.025	22	25.45	
$C_{30}H_{48}$	*d*-α-Amyrilene	C_6H_6	4		109.48	(2067)
	l-α-Amyrilene	C_6H_6	0.871		104.9	
	l-β-Amyrilene	C_6H_6	1.5		112.2	
	Alcohols, Esters and Ethers					
$C_{10}H_{18}O_3$	Ascaridolglycol		1.0981^{20}_{20}		0	(1492)
$C_{11}H_{16}O$	Nortricycloeksantalol		0.9938^{20}		−38.80	(1872)
$C_{11}H_{18}O$	*d*-Tricycloeksantalol		0.989^{18}		7.7	(1921)
$C_{15}H_{14}O_6$	*l*-Catechin (λ = 5790)	50% Me_2CO	*3.49*		16.7	(670)
		EtOH			0	
	l-Epicatechin	EtOH	*2.39*		−68	
		50% Me_2CO	*4.35*		−60	
$C_{15}H_{24}O$	Cedrenol		*1.0083*	20	0	(1930)
$C_{15}H_{24}O$	Vetivenol (tricyclic)		1.0208	20	34.33	(1936)
	(bicyclic)		1.0095	20	25	
$C_{15}H_{24}O$	α-Santalol		0.9788^{15}		1.21	(1872)
$C_{15}H_{26}O$	Eudesmol		0.9884	20	31.25	(1942)
$C_{15}H_{26}O$	Guajol	95% EtOH		25	−26.64	(708)
$C_{15}H_{26}O$	Pseudocedrol		0.9964	20	21.5	(1930)
$C_{15}H_{26}O$	Globulol	$CHCl_3$	*12*	20	−35.48	(1942)
$C_{15}H_{26}O_2$	Calameon	EtOH	*5.04*	26	−8.94	(2016)
$C_{17}H_{24}O_{10}$	Verbenalin	H_2O	2.04		−180.5	(178)
$C_{17}H_{26}O_2$	Vetivenyl (tricyclic) acetate		1.0218	20	28.8	(1936)
$C_{17}H_{28}O_2$	Eudesmyl acetate		0.9933	20	31	(1942)
$C_{17}H_{30}O_2$	Dihydroeudesmyl acetate		0.9776	20	13	(1942)
$C_{19}H_{20}O_6$	Matairesinol	Me_2CO	5.0	15	−4.89	(405)
$C_{19}H_{22}O_6$	Tetramethyl-*l*-catechin	$C_2H_2Cl_4$	*2.27*		12	(670)
	Tetramethyl-*l*-epicatechin (λ = 5790)	$C_2H_2Cl_4$	*2.12*		−61.5	
$C_{20}H_{24}O$	Isoolivile	H_2O	0.397	12	352	(1120.5)
		AcOH	4.024	12	118	(1120.5)
		EtOH	4.036	25	61.1	(1120.5)

* Mutarotation.

Alcohols, Esters and Ethers.—(*Continued*)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{20}H_{24}O_7.H_2O$	Olivile hydrate	H_2O	0.314	12	−127	(1120.5)
$C_{21}H_{18}O_{12}$	Scutellarin	Py aq	3.79	18	−14.0	(731)
$C_{21}H_{28}O_8$	Olivile methylalcoholate	MeOH	6.35	22	−48.9	(1120.5)
$C_{21}H_{34}O_4$	Isopurganol	Py	0.70		−44.9	(1702)
$C_{21}H_{36}O_4$	Trifolianol	Py	1.472		−44.1	(1787)
		$CHCl_3$	1.059		−24.4	(1855)
$C_{22}H_{24}O_7$	Acetyltetramethylhematoxylin	AcOH	1.01	20	152.19	(863)
$C_{22}H_{24}O_{10}$	Homonataloin	H_2O	1.718	20	−102.7	(1188)
$C_{22}H_{28}O_7$	Dimethylolivile	EtOH	0.7687	24	56.4	(1120.5)
	Dimethylisoolivile	EtOH	0.4572	22.5	33.58	(1120.5)
$C_{22}H_{30}O_6$	Olivile ethylalcoholate	EtOH	0.730	28	−23.8	(1120.5)
$C_{23}H_{30}O_7$	Methylethylisoolivile	EtOH	1.355	25	39.36	(1120.5)
		EtOH	2.448	25	46.3	
	Ethylmethyisoolivile	EtOH	0.3045	25	50.35	
$C_{23}H_{40}O_4$	Ipuranol	Py	1.075	15	−37.2	(1703); *cf.* (1695)
$C_{24}H_{32}O_7$	Diethylisoolivile	EtOH	1.1342	22.5	38.2	(1120.5)
$C_{25}H_{24}O_{11}$	*d*-Catechin pentaacetate (λ = 5790)	$C_2H_2Cl_4$	*2.13*		40.6	(670)
	l-Epicatechin pentaacetate	$C_2H_2Cl_4$	*2.12*		−15	
$C_{25}H_{38}O_6$	Diacetylipurganol	Py	1.25		−36.0	(1702)
$C_{25}H_{40}O_6$	Trifolianyl diacetate	$CHCl_3$	1.561		−26.1	(1787)
		$CHCl_3$	0.9740		−25.7	(1708)
$C_{27}H_{42}O.H_2O$	Ergosterol	$CHCl_3$			−126	(2003)
		Et_2O			−105.5	
$C_{28}H_{42}O_2$	Ergosteryl formate				−97.9	(2003)
$C_{29}H_{44}O_2$	Ergosteryl acetate				−91.8	(2003)
$C_{27}H_{44}O$	Cluytiasterol	$CHCl_3$	1.426		−52.6	(2051)
	Cholesterol and derivatives					
$C_{27}H_{43}Br$	Cholesteryl bromide	C_6H_6	3.186	19.5	−19.14	(1122)
$C_{27}H_{43}Br_3$	Tribromocholestane	$CHCl_3$	3.352	19	−49.82	(1122)
$C_{27}H_{43}Cl$	Cholesteryl chloride	C_6H_6	3.09		−26.36	(1402)
$C_{27}H_{44}Cl_2$	Cholesteryl hydrochloride	C_6H_6	3.12		20.1	(1402)
		Et_2O	3.25		12.16	
$C_{27}H_{46}Br_2O$	Cholesterol dibromide		3.17		−41.6	(1402)
$C_{27}H_{46}Cl_2O$	Cholesterol dichloride		3.16		−29.1	(1402)
$C_{27}H_{45}Cl$	Chlorocholestane	$CHCl_3$	3.07	21	4.7	(1403)
$C_{27}H_{45}ClO$	Cholesterol hydrochloride	H_2O?	1.40		5.7	(1402)
$C_{27}H_{46}O$	Cholesterol	AcOEt	3.06	20	−25.64	(387)
		$CHCl_3$	2.1		−40.3	(1857)
		Et_2O	4.9		−29.92	(1402)
$C_{27}H_{46}O_2$	α-Cholesterol oxide	C_6H_6	1.71	20	−37.43	(2171.5)
$C_{27}H_{46}O_4$	Cholesterol ozonide	$CHCl_3$	3.88	20	14.51	(392.5)
$C_{27}H_{48}O$	β-Cholestanol	$CHCl_3$		18	27.4	(393)
$C_{27}H_{48}O$	γ-Cholestanol	Et_2O	2.63	18	29.9	(2193)
	δ-Cholestanol	$CHCl_3$	0.95	18	31.62	
$C_{27}H_{48}O$	Dihydrocholesterol	Et_2O	*10*		18.35	(1499)
		Et_2O	4	22	28.8	(2190)
$C_{29}H_{48}O_2$	Cholesteryl acetate	Et_2O	3.21		−29.8	(1402)
$C_{29}H_{48}Cl_2O_2$	Cholesteryl acetate dichloride	Et_2O	3.29		−32.8	(1402)
$C_{29}H_{48}Br_2O_2$	Cholesteryl acetate dibromide	Et_2O	3.11		−45.1	(1402)
$C_{33}H_{49}NO_2$	Cholesteryl phenylurethane	C_6H_6	2.08	19	−19.9	(153)
	Phytosterol and derivatives					
$C_{20}H_{34}O$	Phytosterol (from colocynth seeds)	$CHCl_3$	1.236		8.1	(1697)
$C_{27}H_{46}O$	Phytosterol	$CHCl_3$	1.196		−40.4	(1452)
		$CHCl_3$	0.9152		−34.4	(1708)
		$CHCl_3$	0.967		−33.6	(1706)
		$CHCl_3$	2.573		−30.1	
$C_{27}H_{46}O$	α-Phytosterol	$CHCl_3$	1.239		−41.7	(1787)
$C_{27}H_{46}O.H_2O$	Phytosterol (verosterol)	$CHCl_3$	1.19		−33.0	(1701)
$C_{28}H_{48}O.H_2O$	(from *Tilia europaea*)	$CHCl_3$	2.5752		−29.7	(1100)
	(from *Matricaria chamomilla*)	$CHCl_3$	4.0356		−29.3	
	(from *Verbascum thapsus*)	$CHCl_3$	1.2556		−3.3	
$C_{29}H_{48}O_2$	Phytosteryl acetate	$CHCl_3$	0.930		−43.9	(1787)

Phytosterol and derivatives.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{30}H_{50}O_2$	Phytosteryl acetate (from *Linaria vulgaris*)	$CHCl_3$	2.5456		−38.61	(1100)
	(from *Tilia europaea*)	$CHCl_3$	2.5180		−37.9	
	(from *Verbascum thapsus*)	$CHCl_3$	2.504		−2.65	
$C_{35}H_{52}O_2$	Phytosteryl benzoate (from *Linaria vulgaris*)	$CHCl_3$	3.9074		−14.55	(1100)
	Sitosterol, coprosterol and derivatives					
$C_{27}H_{40}O_2$	Dehydrositostenedione	$CHCl_3$			−38.9	(1635)
$C_{27}H_{46}O$	Sitosterol	$CHCl_3$	1.509		−32.1	(1695)
		$CHCl_3$	5.5		−34.4	(1635)
$C_{27}H_{46}O$	Sitosterol (from wheat germ)	$CHCl_3$	2.9		−32.2	(1857)
$C_{27}H_{48}O$	Coprosterol	$CHCl_3$		20	24	(393)
		$CHCl_3$	*2.03*	21	23.55	
$C_{34}H_{51}NO_2$	Sitosteryl phenylcarbamate	C_6H_6	3.90	19	−26.03	(1635)
	Withaniol, lippianol, fungisterin, laserpitin, bombicesterol, taraxasterol, ipuranol and derivatives					
$C_{25}H_{34}O_6$	Withaniol	$CHCl_3$	1.872		91.2	(1709)
$C_{25}H_{36}O_4$	Lippianol	EtOH	*0.45*		65	(1714)
$C_{25}H_{40}O$	Homotaraxasterol	$CHCl_3$	0.494		25.3	(1694)
$C_{25}H_{40}O.H_2O$	Fungisterin	2% $EtOH.CHCl_3$			−22.4	(2003)
		Et_2O			−12.9	
$C_{26}H_{40}O_7$	Laserpitin	EtOH	8.11	18.5	118.84	(1460)
		EtOH	5.321	18.5	118.65	
$C_{26}H_{44}O$	Bombicesterol	$CHCl_3$	15.9	15	−34	(1416)
$C_{27}H_{42}O_2$	Acetylhomotaraxasterol	$CHCl_3$	0.444		28.1	(1694)
$C_{27}H_{42}O_3$	Fungisteryl acetate	$CHCl_3$			−15.9	(2003)
		Et_2O			−10.8	
$C_{27}H_{44}O_2$	Bombicesteryl formate	$CHCl_3$	8.4	17.5	−47	(1416)
$C_{27}H_{44}O_6$	Diacetylipuranol	AcOEt	0.491	15	−25.4	(1703)
$C_{28}H_{46}O_2$	Bombicesteryl acetate	$CHCl_3$	15.0	17.5	−42.7	(1416)
$C_{29}H_{48}O$	Taraxasterol	$CHCl_3$	2.171		96.3	(1694)
$C_{31}H_{50}O_2$	Acetyltaraxasterol	$CHCl_3$	1.023		122.2	(1694)
$C_{33}H_{48}O_2$	Bombicesteryl benzoate	$CHCl_3$	4.15	20	−14.63	(1416)
	α-Elaterin, anthesterol and derivatives					
$C_{28}H_{38}O_7$	α-Elaterin	$CHCl_3$	1.560		−68.9	(1697)
$C_{28}H_{48}O$	Anthesterol	Xylene	*2.3*		44.7	(1097)
	α-Anthesterol	Xylene	*2.13*		54.1	
	β-Anthesterol	Xylene	*2.13*		48.3	
$C_{28}H_{50}O$	Anthesterol	$C_2H_4Br_2$	0.756	17	48.3	(1096)
$C_{31}H_{52}O$	Anthesterol anhydride	$CHCl_3$	2.5		75.4	(1099)
$C_{31}H_{52}O.3H_2O$	hydrate	$CHCl_3$	2.5		69.3	(1099)
$C_{33}H_{54}O_2$	Anthesteryl acetate (α-salt)	$CHCl_3$	2.5		91.2	(1099)
		CCl_4	2.5		89.2	
	(β-salt)	$CHCl_3$	2.5		73.9	
$C_{33}H_{53}BrO_2$	Bromanthesteryl acetate (α_1-salt)	C_6H_6	3.0		127.4	(1099)
		C_6H_6	3.0		121.1	
		C_6H_6	3.0		133.0	
	(α_2-salt)	C_6H_6	3.0		63.9	
		C_6H_6	3.0		58.8	
$C_{35}H_{52}O_2.\frac{1}{2}H_2O$	Anthesteryl α-benzoate	CCl_4	*2.5*		64.36	(1097)
	Anthesteryl β-benzoate	CCl_4	*2.5*		71.7	
	Anthesteryl γ-benzoate	CCl_4	*2.5*		66.7	
$C_{36}H_{54}O_2$	Benzoylanthesterol	CCl_4	2.5	16	63.9	(1096)
		CCl_4	1.25		59.9	
	Ledum camphor, micromeritol, amyrin, cedrol, faradiol and derivatives					
$C_{30}H_{30}CrO_4$	Ledum camphor chromate (λ = 6708)	CCl_4	4		30.0	(2177)
$C_{30}H_{46}O_4$	Micromeritol	$CHCl_3$	0.217		61.4	(1707)
$C_{30}H_{48}O_2.2H_2O$	Oxy-α-amyrin	C_6H_6	1.653	15.5	108.6	(2068)
$C_{30}H_{49}BrO$	Bromo-α-amyrin	C_6H_6	2.59	16.3	72.8	(2068)
$C_{30}H_{50}CrO_4$	Cedryl chromate (λ = 6708)	CCl_4	5		79.4	(2177)
$C_{30}H_{50}O$	α-Amyrin	C_6H_6	3.839	16.7	91.59	(2068); *cf.* (892, 1032, 1792)
	β-Amyrin	C_6H_6	1.905	19	99.81	
$C_{30}H_{50}O_2$	Faradiol	Me_2CO	1.254	20	45.1	(1098)

Ledum camphor, micromeritol, amyrin, cedrol, faradiol and derivatives.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{32}H_{52}O_2$	α-Amyrin acetate	C_6H_6	3.6		77.9	(1032); *cf.* (1792)
	α-Amyrin acetate	C_6H_6	4.074	17.6	77.0	(2068)
	β-Amyrin acetate	C_6H_6	4.15	16.7	78.6	
$C_{33}H_{52}O_4$	Micromerol	EtOH	3.22		57	(1707)
$C_{34}H_{54}O_4$	Faradiol acetate	C_6H_6	4.0316	14	63.6	(1098)
$C_{35}H_{54}O_5$	Micromeryl acetate	$CHCl_3$	0.352		47.1	(1707)
$C_{36}H_{58}O_4$	Faradiol propionate	C_6H_6	3.0	20	62.3	(1098)
$C_{37}H_{54}O_2$	α-Amyrin benzoate	C_6H_6	3.4		93.58	(1032)
	Other alcohols and their derivatives					
$C_{31}H_{34}O_{14}$	Pentaacetylrhapontin	AcOH	2	15	−11.6	(897)
$C_{32}H_{44}O_7$	Somnirol	$CHCl_3$	0.718		34.8	(1709)
$C_{33}H_{36}O_{15}$	Hexaacetylrhapontin	AcOH	2	15	−30.4	(897)
$C_{33}H_{46}O_7$	Somnitol	$CHCl_3$	1.216		21.2	(1709)
$C_{35}H_{54}O_5$	Diacetylprunol	$CHCl_3$	0.907		62.4	(1698)
$C_{37}H_{44}O_6$	Dibenzoylcalabarol	$CHCl_3$	2.947		14.7	(1855)
$C_{37}H_{58}O_9$	Tetraacetylcluytianol	AcOEt	0.988		−20.2	(1694)
$C_{41}H_{39}ClO_{21}.2H_2O$	Delphinine chloride (λ = 6563)	1% HCl	0.013		−1364.0	(2191)
	(λ = 6140)	1% HCl	0.013		−2273.0	(2191)
$C_{43}H_{68}O_6$	Caulosapogenin monomethyl ether	$CHCl_3$	0.0706		74.4	(1710)
$C_{55}H_{80}O_{25}$	Gegosaponin	90% EtOH	1.46		−39.15	(55)
$C_{58}H_{92}O_9$	Caulophyllosapogenin dimethyl ether	$CHCl_3$	0.612		43.6	(1710)
$C_{66}H_{104}O_{17}$	Caulophyllosaponin	$CHCl_3$	0.800		32.3	(1710)
$C_{70}H_{82}O_{10}$	Tetrabenzoylcaulosapogenin	$CHCl_3$	1.546		111.0	(1710)
	Aldehydes and Ketones					
$C_{15}H_{12}O_6$	Eriodictyonone	AcOEt	*4.78*	20	−28.21	(1463)
$C_{15}H_{23}NO_2$	*d*-Longif-1, 2-dione monoxime	EtOH		30	121.3	(1949)
$C_{15}H_{23}NO_3$	Tetrahydrosantonin oxime	$CHCl_3$	1.057	15	−17.9	(2145)
		$CHCl_3$	*2.8*	20	−17.78	(54)
$C_{15}H_{24}O$	β-Santalol		0.9909^{15}		−41.53	(1872)
$C_{15}H_{24}O_2$	*d*-Longif-1-ol-2-one	EtOH		30	100.8	(1949)
$C_{21}H_{24}N_2O_3$	Artemisin hydrazone	95% EtOH	*1.8128*	24	180	(122)
		95% EtOH	*2.2472*	24	180	(122)
$C_{24}H_{30}O_5$	Elaterone	$CHCl_3$	1.092		120.5	(1451)
$C_{30}H_{34}O_6$	Artemisone	AcOH	*1.10*	18.5	159	(124)
	Isoartemisone	EtOH	*1.45*	19.5	−157	(124)
		AcOH	1.06	13	−153	
$C_{30}H_{48}O$	Euphorbone	$CHCl_3$	*3.02*	15	16.46	(427)
	Carboxylic Acids					
	Picrotoxinonic, picrotinic acids and derivatives					
$C_{14}H_{16}O_8$	Picrotoxinonic acid	EtOH	2.515	17.5	102.38	(931)
$C_{15}H_{15}BrO_7.\frac{1}{2}H_2O$	Bromopicrotoxic acid	EtOH	4.15	17	−96.38	(33)
$C_{15}H_{17}BrO_7$	α-Bromopicrotoxininic acid	H_2O	2.82	17.5	−58.03	(928)
$C_{15}H_{18}O_7$	α-Picrotoxininic acid	EtOH	5.99	17.5	−4.93	(928)
	β-Picrotoxininic acid	EtOH	9.25	17.5	−48.0	
$C_{15}H_{18}O_8$	Picrotoxinonic acid methyl ether	EtOH	1.283	17.5	108.5	(931)
$C_{15}H_{20}O_7$	Dihydropicrotoxininic acid	EtOH	3.01	17.5	−4.17	(928)
		EtOH	3.083	17.5	94.88	(931)
$C_{15}H_{20}O_8$	α-Picrotinic acid	EtOH	3.909	17.5	73.3	(927)
	γ-Picrotinic acid	EtOH	2.096	17.5	4.23	(930)
	δ-Picrotinic acid	EtOH	4.099	17.5	71.58	
	Potassium γ-picrotinate	H_2O	9.287	17.5	−3.57	(930)
$C_{16}H_{20}O_7$	Methyl α-picrotoxininate	EtOH	1.02	17.5	−9.73	(928)
	Methyl β-picrotoxininate	EtOH	1.05	17.5	−50.05	
$C_{16}H_{20}O_8$	Methyl picrotoxinonate methyl ether	EtOH	1.149	17.5	111.50	(931)
$C_{16}H_{22}O_7$	Methyl dihydropicrotoxininate	EtOH	2.584	17.5	70.26	(931)
$C_{16}H_{22}O_8$	Methyl α-picrotinate	EtOH	2.790	17.5	79.15	(927)
	Methyl δ-picrotinate	EtOH	5.960	17.5	77.11	
$C_{17}H_{22}O_7$	Ethyl α-picrotoxininate	EtOH	4.24	17.5	−8.07	(928)
	Ethyl β-picrotoxininate	EtOH	2.44	17.5	49.95	
$C_{17}H_{24}O_7$	Ethyl dihydropicrotoxininate	EtOH	2.752	17.5	70.85	(931)
$C_{17}H_{24}O_8$	Ethyl α-picrotinate	EtOH	4.082	17.5	78.60	(930)
	Ethyl δ-picrotinate	EtOH	6.025	17.5	74.25	(927)
$C_{19}H_{28}O_8$	Diethyl picrotoxinindicarboxylate	EtOH	1.259	17.5	37.4	(929)

Santonin and related compounds

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_{15}H_{18}Br_2O_4$	Dibromoparasantonic acid	EtOH	3.39		28.0	(622)
$C_{15}H_{17}ClO_3.H_2O$	Chlorosantonin	50% EtOH	2	20	−54.75	(2148)
$C_{15}H_{18}O_3$	Santonin	MeOH	2.065	15	−171.0	(2145)
$C_{15}H_{18}O_3$	Parasantonide	$CHCl_3$			891.7	(622, 622.5)
		$CHCl_3$			744.6	
$C_{15}H_{18}O_4$	δ-Hydroxysantonin	$CHCl_3$	4	18	−108.62	(2148)
$C_{15}H_{19}ClO_5$	Dihydrodihydroxyparasantonic acid chlorohydrin	EtOH	0.62	25	−23.5	(622)
$C_{15}H_{19}NO_2$	Parasantonimide	EtOH	2.67		1135	(622)
$C_{15}H_{20}NO_4$	α-Santoninhydroxyoxime	90% EtOH	1.27	12	219.6	(624)
		96% EtOH	1.26	12	126.8	
$C_{15}H_{20}N_2O_7$	α-Dinitrotetrahydrosantonin	$CHCl_3$	0.971	15	105.0	(2145)
		$CHCl_3$	1.053	15	90.2	
$C_{15}H_{20}O_4$	Isosantonic acid	$CHCl_3$			−73.92	(622)
$C_{15}H_{20}O_5$	Hydroxyparasantonic acid	EtOH	3.27	27.2	89.8	(622)
$C_{15}H_{20}O_6$	Dihydroxyparasantonic acid	EtOH	2.62	27.2	−31.55	(622)
$C_{15}H_{20}O_7$	Santononic acid	EtOH	0.820	20	24.03	(2143)
		$CHCl_3$	0.776	20	24.49	
$C_{15}H_{21}BrO_3$	α-Monobromotetrahydrosantonin	$CHCl_3$	1.650	15	9.09	(2145)
$C_{15}H_{21}NO_4$	Hydroxamsantolic anhydride	EtOH	1.57	25	−214.33	(625)
$C_{15}H_{22}N_2O_4$	α-Santoninhydroxylamineoxime	96% EtOH	8.98	12	47.41	(623)
		96% EtOH	8.82	12	−3.00	
$C_{15}H_{22}O_5$	Santolic acid	EtOH	0.99	27	90.65	(625)
$C_{15}H_{22}O_3$	Tetrahydrosantonin	$CHCl_3$	*4.37*	25	60.56	(54)
		EtOH	1.366	15	23.4	(2145)
		$CHCl_3$	1.070	15	28.0	
$C_{16}H_{22}O_5$	Methyl hydroxyparasantonate	EtOH	1.51	25.6	36.4	(622)
$C_{16}H_{23}N_3O_4$	Santonic acid semicarbazone	EtOH	1.68	25	13.39	(625)
$C_{17}H_{21}NO_3$	Acetylparasantonimide	EtOH	1.30	25	697.2	(622)
$C_{17}H_{22}O_6$	Acetoxyparasantonic acid	EtOH	0.62	25.7	64.3	(622)
$C_{19}H_{27}ClO_5$	Ethyl dehydrodihydroxyparasantonate dichlorohydrin	EtOH	1.61	26	−97.0	(622)
$C_{30}H_{40}N_2O_6$	Santonic acid hydrazone	AcOH	1.87	24.8	−86.75	(625)
	Other Carboxy Compounds					
$C_8H_{13}NO_4$	Cincholoiponic acid	H_2O	*4*	20	30.9	(2219); *cf.* (1882, 1959, 1964)
$C_{12}H_{15}N$	Tricycloeksantalic acid nitrile		0.990^{15}		14.4	(1921)
$C_{13}H_{14}O_9.2H_2O$	Glucogallic acid	very dil. Me_2CO	5.0	17	10.6	(449)
$C_{13}H_{20}O_2$	Santalenic acid	90% EtOH	10	20	18.05	(284)
$C_{14}H_{12}O_9$	*d*-Leucodigallic acid	EtOH	0.3246	17	56.4	(1515)
		H_2O	0.4124	19	104	
	l-Leucodigallic acid	EtOH	0.4004	18	−67.61	
		H_2O	0.4082	15	−64.58*	
$C_{14}H_{27}NO_3$	Carpamic acid	H_2O	3.727		7.0	(87)
$C_{15}H_{24}O_4$	*l*-α-Longiforic acid	EtOH		30	−23.47	(1949)
	l-β-Longiforic acid	EtOH		30	−49.3	
$C_{16}H_{24}O_2$	Methyl vetivenate		1.0372^{20}	10	42.2	(1936)
$C_{16}H_{28}O_2$	Hydnocarpusic acid	C_6H_6		20	70.0	(1195)
$C_{16}H_{28}O_2$	Hydnocarpic acid	$CHCl_3$	0.525		68.1	(1693)
$C_{16}H_{29}NO$	Hydnocarpamide	$CHCl_3$	1.78		70.2	(1693)
$C_{17}H_{30}O_2$	Methyl hydnocarpate	$CHCl_3$	3.93		62.4	(1693)
$C_{18}H_{16}O_7$	*d*-Usninic acid	$CHCl_3$	*2.07*	11.5	49.5	(2174)
$C_{18}H_{32}O_2$	Ethyl hydnocarpate	$CHCl_3$	2.04		51.6	(1693)
$C_{19}H_{22}O_7.3H_2O$	Matairesinolic acid (*a*) anhydrous	Me_2CO	14.45	20	−3.46	(405)
	(*b*) hydrated	Me_2CO	14.45	20	−3.04	
	(*c*) lactone	Me_2CO	14.45	20	−3.65	
$C_{20}H_{18}O_5$	Isocubebic ether	C_6H_6	2.48		26.02	(1367)
$C_{20}H_{18}O_6$	Cubebinolide	$CHCl_3$	4.141	16	33.69	(1367)
$C_{20}H_{30}O_5$	Andrographolide	AcOH	2	26	−126	(742)
$C_{20}H_{32}O_6$	Andrographolic acid	MeOH	2.466	26	14.4	(742)

*Mutarotation.

Other Carboxy Compounds.—(*Continued*)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{21}H_{21}ClO_6$	Cubebinolide hydrochloride methyl ester	$CHCl_3$	4.79	16	13.9	(1367)
$C_{21}H_{28}O_4$	Marrubiin	Me_2CO	4.79	24	45.68	(737)
$C_{21}H_{30}O_5$	Marrubic acid	Me_2CO	2.55	21.5	7.86	(737)
$C_{23}H_{38}O_7$	Elateric acid	AcOEt	1.60		23.9	(1451)
$C_{24}H_{21}NO_6$	*d*-Usninic anilide	$CHCl_3$	*2.53*	16	28.6	(2174)
$C_{24}H_{22}O_{14}$	*d*-Pentaacetylleucodigallic acid	Me_2CO	0.2824	18	76.4	(1515)
$C_{24}H_{28}O_6$	Casimirolide	$CHCl_3$	1.542		−49.2	(1695)
$C_{24}H_{30}O_7$	Casimiroic acid	EtOH	0.835		−86.8	(1695)
$C_{24}H_{34}O_2$	Cholanetrienecarboxylic acid	$CHCl_3$	*4.83*	20	−19.7	(2175)
$C_{24}H_{40}O_2$	Cholanecarboxylic acid	$CHCl_3$	*6.51*	20	20.3	(2175)
$C_{24}H_{40}O_4$	Desoxycholic acid	EtOH	*6.64*	20	53.28	(1166)
$C_{24}H_{40}O_4$	Choleinic acid	EtOH	*4.84*	20	47.97	(1166)
$C_{26}H_{42}NO_6Na$	Glycocholic acid, sodium salt	H_2O	8.44	13	24.3	(1203)
		90% EtOH	2.42		27.8	
$C_{26}H_{43}NO_6$	*d*-Glycocholic acid	96% EtOH	1.79	7	32.3	
$C_{27}H_{45}NO_6$	Glycocholic acid	Et_2O	4		4.57	(1646)
$C_{30}H_{42}O_9$	Photosantoninic acid	EtOH	1.99	15	−9.88	(626)
$C_{32}H_{28}O_5$	Diphenylcubebinolide	$CHCl_3$	5.97	16	−178.8	(1367)
$C_{32}H_{36}O_{21}$	*d*-Hexacarbethoxyleucodigallic acid	EtOH	0.3964	18	62.5	(1515)
	l-Hexacarbethoxyleucodigallic acid	EtOH	0.3648	15	−57.35	
$C_{32}H_{38}O_{19}$	Chlorogenic acid	H_2O	*2.75*	26	−35.2	(744)
	Nitrogen Compounds, Mainly Alkaloids					
	Morphine ($C_{17}H_{19}NO_3$) *and related compounds*					
$C_{17}H_{18}BrNO_2$	Bromomorphide	MeOH	2.837	25	65.9	(1895)
$C_{17}H_{18}ClNO_2$	β-Chloromorphide	MeOH	3.975	15	−5	(1108)
$C_{17}H_{18}ClNO_2$	Chloromorphide	MeOH	0.573		−375.2	(1895)
$C_{17}H_{19}Cl_2NO_2$	Chloromorphide hydrochloride	H_2O	1.67	20	−315.3	(1895)
$C_{17}H_{19}Br_2NO_2$	Bromomorphide hydrobromide	H_2O	3.157	27	41.1	(1895)
$C_{17}H_{19}BrClNO_2$	Chloromorphide hydrobromide	H_2O	1.65	19	−268.6	(1895)
$C_{17}H_{19}NO_3$	Isomorphine	MeOH	2.01	25	−164.3	(1895)
$C_{17}H_{19}NO_3$	α-Isomorphine	MeOH	2.95	15	−167	(1534)
	β-Isomorphine	MeOH	1.63	17	−216	(1896)
	γ-Isomorphine	MeOH	1.795	15	−94	
$C_{17}H_{20}BrNO_3$	Isomorphine hydrobromide	H_2O	2.49	15	−127.2	(1895)
	γ-Isomorphine hydrobromide	H_2O	1.885	15	−71	(1534)
$C_{17}H_{20}ClNO_2$	Desoxymorphine hydrochloride	H_2O?	2.36	27	140.3	(1895)
$C_{17}H_{20}ClNO_3$	Neoisomorphine hydrochloride	H_2O	1.84		−79.1	(1184)
	β-Isomorphine hydrochloride	H_2O	2.26	11	−200.8	(1896)
	γ-Isomorphine hydrochloride	H_2O	1.888	15	−76	(1534)
$C_{18}H_{19}NO_2$	Apomorphine 3-methyl ether	EtOH	8.4	15	−90	(1113)
		$CHCl_3$	2.6	15	−103	
$C_{18}H_{19}NO_2$	Methylapomorphine	EtOH	*1.06*	22	66.83	(1726)
$C_{18}H_{22}INO_3$	Morphine methiodide	H_2O	1.162	25	−72.9	
	Isomorphine methiodide	H_2O	1.696	23	−91.5	(1895)
	γ-Isomorphine methiodide	H_2O	1.540	15	−50	(1534)
	Neoisomorphine methiodide	H_2O	1.56		−54.5	(1184)
$C_{19}H_{21}NO_2$	Apomorphine dimethyl ether	EtOH	1.639	15	−148	(1113)
$C_{19}H_{22}BrNO_3$	Bromo-α-methylmorphimethine	EtOH	1.23	15	−104.06	(2075)
	Bromo-β-methylmorphimethine	EtOH	0.713	15	128.22	
$C_{19}H_{22}INO_2$	Methylapomorphine methiodide	MeOH	1.257	15	−20	(1113)
		H_2O	*0.952*	21	10.48	(1726)
$C_{19}H_{22}NIO_2$	Dimethylapomorphine hydroiodide	EtOH	1.379	15	−49	(1113)
$C_{19}H_{23}NO_3$	β-Methylmorphimethine	EtOH	1	17	438	(1114)
	δ-Methylmorphimethine	MeOH	1.24	15	256.6	
	γ-Methylmorphimethine	$CHCl_3$	3.09	20	64.6	
		$CHCl_3$	0.574	20	67	(1725)
	ε-Methylmorphimethine	99% EtOH		15	−120.1	(1104)
	δ-Methylmorphimethine	EtOH	8.91	15	−174	(1110)
$C_{19}H_{24}ClNO_3$	ε-Methylmorphimethine hydrochloride	H_2O		15	−154	(1104)
$C_{19}H_{24}INO_3$	γ-Methylmorphimethine hydroiodide	H_2O	0.811	20	37	(1725)
	ε-Methylmorphimethine hydroiodide	H_2O	0.805	20	−95.6	
$C_{20}H_{24}INO_2$	Dimethylapomorphine methiodide	H_2O	*2.67*	21	−42.03	(1726)
$C_{20}H_{25}BrINO_3$	Bromo-α-methylmorphimethine methiodide	EtOH	0.56	15	−110.71	(2075)

Morphine ($C_{17}H_{19}NO_3$) and related compounds.—(Continued)

Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{20}H_{25}NO_3$	α-Dimethylmorphimethine	MeOH	2.085	24	−251.9	(1724)
$C_{20}H_{26}INO_3$	α-Methylmorphimethine methiodide	H_2O	10	17	−12.7	(1106)
	β-Methylmorphimethine methiodide	97% EtOH	0.6	17	233	(1106)
	γ-Methylmorphimethine methiodide	H_2O	1.56	17	34.7	(1896)
	δ-Methylmorphimethine methiodide	EtOH	1.00	15	150.7	(1106)
	ε-Methylmorphimethine methiodide	H_2O	0.951	20	−110.4	(1725)
		H_2O			−111	(1104)
	ζ-Methylmorphimethine methiodide	H_2O	2.486	15	−148	(1110)
$C_{21}H_{25}NO_4$	Acetylmethylmorphimethine	$CHCl_3$	5.66	21	150	(1111)
$C_{21}H_{28}INO_3$	α-Dimethylmorphimethine methiodide	H_2O	0.260	23	−134.4	(1724)
	β-Dimethylmorphimethine methiodide	H_2O	0.229	22	268.5	
		H_2O	0.213	22	278.5	
	γ-Dimethylmorphimethine methiodide	H_2O	0.642	20	14	(1724, 1725)
	δ-Dimethylmorphimethine methiodide	H_2O	0.146	28	171	(1724)
	ε-Dimethylmorphimethine methiodide	H_2O	0.283	20	−79	
$C_{22}H_{26}INO_5$	Diacetylmorphine methiodide	H_2O	0.896	15	−107	(1534)
	Diacetyl-γ-isomorphine methiodide	H_2O	1.273	15	−24	(1534)
$C_{22}H_{28}BrNO_5$	Bromoacetoxydihydro-α-dimethylmorphimethine methyl ether	MeOH	2.468	26	108.4	(1723)
$C_{22}H_{28}INO_4$	Acetyl-ε-methylmorphimethine methiodide	H_2O			−45	(1104)
$C_{26}H_{29}NO_5$	α-Methylmorphinemethine benzoate	H_2O	1.0	16	−112.8	(1106)
	β-Methylmorphimethine benzoate	H_2O	1	17	254	(1106)
	δ-Methylmorphimethine benzoate	EtOH	0.63	15	181.1	(1106)
	γ-Methylmorphimethine benzoate	99% EtOH	0.87	15	41.3	(1106)
$C_{31}H_{25}NO_4$	Dibenzoylapomorphine	$CHCl_3$	*3.33*	17	43.44	(1726)
	Codeine (methylmorphine), thebaine (dimethylmorphine) and related compounds					
$C_{18}H_{19}NO_3$	Codeinone	EtOH	1.007	15	−205	(21)
$C_{18}H_{19}NO_3$	Isocodeinone	99% EtOH	2.11	15	−25	(1107)
$C_{18}H_{20}ClNO_2$	β-Chlorocodide	EtOH	0.824	15	−10	(1108)
	Chloro-ψ-codeine	99% EtOH		15	−100.8	(1104)
$C_{18}H_{20}BrNO_3$	Bromo-ψ-codeine	EtOH		15	−75.2	(1104)
$C_{18}H_{20}INO_2$	Iodocodide	$CHCl_3$	3.95	20	136.5	(1105)
$C_{18}H_{20}N_2O_3$	Codeinone oxime	EtOH	0.139	15	−499	(21)
$C_{18}H_{20}N_2O_5$	Nitro-ψ-codeine	$CHCl_3$		15	−49.9	(1104)
$C_{18}H_{21}NO_2$	Desoxycodeine	EtOH	4.922	15	121	(1115)
$C_{18}H_{21}NO_3$	Codeine	97% EtOH	5.0	15	−135.8	(885.5); *cf.* (784.5)
		$CHCl_3$	2	15	−111.5	
		$CHCl_3$	4	23	−115.63	(901)
	Allo-ψ-codeine	EtOH	4.5	15	−228	(1110)
	ψ-Codeine	EtOH	*1.91*		−91.1	(1417)
	Neoisocodeine	EtOH	3.53		−96.6	(1184)
	Isocodeine	$CHCl_3$	1.87		−150.6	
$C_{18}H_{21}NO_4$	Codeine oxide	H_2O	2.08	18	−97.1	(1466)
$C_{18}H_{21}NO_6S$	β-Codeinesulfonic acid	H_2O	3.024	20	−190.1	(1675)
$C_{18}H_{21}NO_7S$		*N* KOH	4.23	20	−136.3	
	Codeinehydroxysulfonic acid	2*N* KOH	4.17	20	−115.4	(675)
$C_{18}H_{22}ClNO_3.2H_2O$	Codeine hydrochloride	H_2O	2	22.5	−108.2	(881.2, 2053)
$C_{18}H_{22}ClNO_4$	Codeine oxide hydrochloride	H_2O	2.08	20	−105.8	(1466)
$C_{18}H_{22}INO_3$	Allo-ψ-codeine hydroiodide	EtOH	1.967	15	−153	(1110)
	ψ-Codeine hydroiodide			15	−57	
$C_{18}H_{23}NO_2$	Desoxydihydrocodeine	EtOH	5.171	15	−24	(1115)
$C_{18}H_{24}ClNO_2$	Desoxydihydrocodeine hydrochloride	H_2O	5.289	15	−17	(1115)
$C_{19}H_{22}INO_3$	Isocodeinone methiodide	H_2O	0.893	15	−12	(1107)
$C_{19}H_{21}NO_3$	Thebaine	$CHCl_3$	5	22.5	−229.5	(885.5)
		97% EtOH	2	15	−218.6	
$C_{19}H_{22}ClNO_3$	Thebaine hydrochloride	H_2O	2	22.5	−163.25	(885.5)
$C_{19}H_{23}ClINO_2$	ψ-Chlorocodide methiodide				−227.4	(1104)
$C_{19}H_{23}INO_3$	β-Isocodeine methiodide	H_2O	0.603		−145.5	
$C_{19}H_{24}INO_3$	Allopseudocodeine isomethiodide	H_2O	1.728	15	−142	(1110)
$C_{19}H_{25}NO_7S$	Methylhydroxycodeinesulfonic acid	H_2O	1.76	20	−63.2	(675)

Codeine (methylmorphine), thebaine (dimethylmorphine) and related compounds.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{20}H_{23}NO_4$	Acetocodeine	$CHCl_3$	4.579	21	−141	(1111)
$C_{20}H_{26}INO_2$	Methyldesoxycodeine methiodide	EtOH	2.290	15	108	
$C_{20}H_{26}INO_3$	Methylcodeine methiodide	H_2O	0.6013	22	−107.2	(1724)
$C_{20}H_{28}INO_2$	Methyldesoxydihydrocodeine methiodide	99% EtOH	2.773	15	−12	(1115)
$C_{21}H_{26}INO_4$	Acetylcodeine methiodide	H_2O	1.03	15	−64	(1111)
$C_{22}H_{25}NO_5$	Acetoacetylcodeine	$CHCl_3$	5.72	17	−207	(1111)
	Acetoacetyl-ψ-codeine	$CHCl_3$	5.49	18	−126	(1112)
	Acetoacetylisocodeine	$CHCl_3$	5.15	14	−236	(1112)
$C_{25}H_{26}NO_4$	Desoxycodeine benzoate	EtOH	5.53	15	106	(1115)
$C_{25}H_{27}NO_3$	Pseudocodeine *p*-cresyl ether	$CHCl_3$	2.78	20	−13.7	(1105)
$C_{25}H_{27}NO_4$	Pseudocodeine guaiacyl ether	$CHCl_3$	0.9610	20	−22.9	(1105)
$C_{27}H_{27}NO_5$	Codeine phenylpropiolate	$CHCl_3$	4	23	−51.00	(901)
		$CHCl_3$	1	23	−50.50	
		H_2O	1	22	−76.00	
$C_{27}H_{29}NO_5$	Codeine cinnamate	$CHCl_3$	4	23	−51.63	(901)
		$CHCl_3$	1	23	−52.50	
		H_2O	1	22	−75.00	
$C_{27}H_{31}NO_5$	Codeine β-phenylpropionate	$CHCl_3$	4	23	−64.37	(901)
		H_2O	1	22	−88.00	
$C_{36}H_{44}N_2O_9$	Bimolecular codeine oxide	H_2O	2.51	20	−97.6	(1466)
		EtOH	2.51	19	−105.9	
	Hydrated	H_2O	2.46	20	−99.5	(1466)
		EtOH	2.50	19	−107.2	
$C_{36}H_{44}N_2O_{10}S.5H_2O$	Codeine sulfate	H_2O	3	25	−100.9	(885.5)
$C_{40}H_{44}N_2O_{10}$	Codeine acetylenedicarboxylate	$CHCl_3$	4	22	−76.62	(901)
		$CHCl_3$	1	22	−68.00	
		H_2O	1	22	−87.50	
$C_{40}H_{46}N_2O_{10}$	Codeine fumarate	$CHCl_3$	4	22	−81.50	(901)
		$CHCl_3$	1	22	−83.00	
		H_2O	1	22	−90.00	
$C_{40}H_{46}N_2O_{10}$	Codeine maleate	$CHCl_3$	4	22	−80.75	(901)
		$CHCl_3$	1	22	−80.00	
		H_2O	1	22	−93.00	
$C_{40}H_{48}N_2O_{10}$	Codeine succinate	$CHCl_3$	4	23	−87.75	(901)
		$CHCl_3$	1	23	−90.00	
		H_2O	1	25	−103.00	
Cinchonine, cinchonidine and their derivatives; cf. (866, 875, 876, 885.5, 1026, 1027, 1028, 1030, 1187, 1196, 1543.5, 1794, 1963, 2070, 2223, 2223.5)						
$C_{19}H_{21}BrN_2O$	Bromocinchonidine	33% $EtOH.CHCl_3$	2	17	−110.3	(290)
$C_{19}H_{21}BrN_2O$	Bromocinchonine	33% $EtOH.CHCl_3$	2.03	17	185.7	(289)
$C_{19}H_{21}ClN_2$	Cinchonine chloride	EtOH	1.975	13	57.7	(1756)
		$CHCl_3$	2.007	13	62.2	
$C_{19}H_{21}ClN_2.2H_2O$	Hydrated	EtOH	2.009	13	49.77	
$C_{19}H_{21}ClN_2$	Cinchonidine chloride	EtOH	2.020	13	78.2	(1756)
		$CHCl_3$	2.009	13	90.9	
$C_{19}H_{22}Br_2N_2O$	β-Cinchonine dibromide	33% $EtOH.CHCl_3$	1.0	17	107.5	
$C_{19}H_{22}Br_2N_2O$	β-Cinchonidine dibromide	33% $EtOH.CHCl_3$	2.1	17	−135	(291)
$C_{19}H_{22}Cl_2N_2$	Cinchonidine chloride monohydrochloride	H_2O	1.573	24	24.16	(1756)
$C_{19}H_{22}Cl_2N_2$	Cinchonine chloride monohydrochloride	H_2O	1.555	22	48.86	(1756)
$C_{19}H_{22}N_2O$	Cinchonine	$CHCl_3$	0.560	17	209.6	(1540)
		EtOH	0.6060	20	225.2	(1756)
$C_{19}H_{22}N_2O$	Cinchonidine; *cf.* (329, 875, 876, 885.5, 1196, 1540, 1784)	EtOH	0.878	11	−111.0	(1756)
		$CHCl_3$	1.095	14	−86.7	
$C_{19}H_{22}N_2O$	Isocinchonidine; for various isomerides, *cf.* (866, 875)	$CHCl_3$	1.96		−128	(1554)
		97% EtOH	2.99		−129	
$C_{19}H_{22}N_2$	Desoxycinchonine	EtOH	1.965	20	181.2	(1756)
		$CHCl_3$	2.030	13	194.3	
$C_{19}H_{22}N_2$	Desoxycinchonidine	EtOH	2.006	13	−29.9	
		$CHCl_3$	2.006	13	−19.7	

Cinchonine, cinchonidine and their derivatives; cf. (866, 875, 876, 885.5, 1026, 1027, 1028, 1030, 1187, 1196, 1543.5, 1794, 1963, 2070, 2223, 2223.5).—*(Continued)*

Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{19}H_{22}N_2O$	Apocinchonidine	EtOH	0.8	15	−129.2	
	β-Cinchonidine	EtOH	0.5	20	−171.5	
	γ-Cinchonidine	EtOH	0.5	20	−164.6	(875, 1512)
$C_{19}H_{22}N_2O$	Hydrocinchoninone	EtOH	4.12	21	75.8	(1045)
$C_{19}H_{23}ClN_2O$	Cinchonine hydrochloride	$CHCl_3$	1.407	23	132.9	(1756)
$C_{19}H_{23}ClN_2O$	Cinchonidine hydrochloride (other salts; *cf.* (1540, 1543, 2235))	$CHCl_3$	2.85	15	−24.2	(885.5); *cf.* (1540)
$C_{19}H_{23}ClN_2O.H_2O$	Hydrated	97% EtOH	3	15	−108.0	
		2*N* HCl	10	20	−142.1	(876)
$C_{19}H_{23}IN_2O$	Isocinchonidine hydroiodide	$CHCl_3$	2.0		−58	(1554)
		97% EtOH	3.03		−58	
$C_{19}H_{23}N_3O_4$	Cinchonine nitrate	H_2O	1.54	17	−99.9	(1540)
		EtOH	1.54	17	−103.2*	
$C_{19}H_{24}Cl_2N_2O$	Cinchonine dihydrochloride	H_2O	3.67	20.8	205.5	(1445)
		H_2O	3.55	84	192.8	
$C_{19}H_{24}N_2O$	Cinchonamine; *cf.* (46, 46.5, 881)	H_2O	3	15	206.1	(885.5)
		EtOH	2		120	(934)
		97% EtOH	2	15	121.1	(882)
$C_{19}H_{24}N_2O$	Hydrocinchonine	EtOH	0.406	12	192.1	(1756)
$C_{19}H_{24}N_2O$	Hydrocinchonidine	97% EtOH	2	15	−98.4	(875.5); *cf.* (880)
$C_{19}H_{24}N_2O_5S$	Cinchonine hydrogen sulfate	H_2O	3.92	20.8	195.0	(1445)
		H_2O	3.77	89.3	175.5	
$C_{19}H_{24}N_2O_5S$	Cinchonidine hydrogen sulfate	80% EtOH	2	15	−109.0	(885.5)
$C_{19}H_{28}N_2O$	Hexahydrocinchonine	EtOH	17.8	20	170.2	(1957)
$C_{19}H_{28}N_2O$	Hexahydrocinchonidine	EtOH	4.8	17	−82	
$C_{19}H_{34}N_2O$	Dodecahydrocinchonidine	EtOH	3.75	17	−51	(1957)
$C_{20}H_{22}N_2O_3$	Acetylcinchoninal	$CHCl_3$	1	21	28.2	(1917)
$C_{20}H_{24}N_2O$	Methylcinchotoxine	$CHCl_3$	2.23	20	35.28	(1757)
$C_{21}H_{24}N_2O_2$	Acetylcinchonine	H_2O	2	15	139.5	(1917)
		3*N* $HCl.CHCl_3$	1.18	16.8	110.4	
$C_{21}H_{28}Cl_2N_2O$	Ethylcinchotoxine dihydrochloride	H_2O	0.38	15	51.75	(351)
$C_{23}H_{24}N_2O_5$	Cinchonine acetylenedicarboxylate	$CHCl_3$	4	22	119.75	(901)
		$CHCl_3$	1	22	133.50	
		H_2O	0.5	22	137.00	
$C_{23}H_{28}N_2O_5$	Cinchonine succinate	$CHCl_3$	4	22	159.0	(901)
		$CHCl_3$	1	22	165.0	
		H_2O	0.5	23	140	
$C_{23}H_{26}N_2O_5$	Cinchonine fumarate	$CHCl_3$	4	22	145.63	(901)
		$CHCl_3$	1	22	140.00	
		H_2O	0.5	22	139.00	
$C_{23}H_{26}N_2O_5$	Cinchonine maleate	$CHCl_3$	4	22	117.75	(901)
		$CHCl_3$	1	22	125.00	
		H_2O	0.5	23	143	
$C_{25}H_{24}N_2O_3$	Benzoylcinchoninal	$CHCl_3$	1	22.2	−72.4	(1917)
$C_{25}H_{28}N_2O_3S$	Cinchonine benzenesulfinate	$CHCl_3$	5	23	111.4	(903)
		$CHCl_3$	2.5	23	123.6	
$C_{25}H_{28}N_2O_4S$	Cinchonine benzenesulfonate	$CHCl_3$	5	21	90.2	(903)
$C_{26}H_{26}N_2O_2$	Benzoylcinchonine	H_2O	1	20.2	−24.7	(1917)
$C_{26}H_{28}N_2O_3$	Cinchonine monobenzoate	$CHCl_3$	5	21	141.1	(902)
$C_{26}H_{28}N_2O_4$	Cinchonine monosalicylate	$CHCl_3$	5	21	142.3	(901)
		$CHCl_3$	2.5	21	157.8	
$C_{26}H_{29}N_3O_3$	Cinchonine anthranilate	$CHCl_3$	5	21	162.8	(902)
		$CHCl_3$	2.5	21	176.6	
$C_{26}H_{30}N_2O_3S$	Cinchonine *p*-toluenesulfinate	$CHCl_3$	5	21	100.3	(903)
		$CHCl_3$	2.5	21	107.6	
$C_{26}H_{30}N_2O_4S$	Cinchonine *p*-toluenesulfonate	$CHCl_3$	5	21	94.6	(903)
		$CHCl_3$	2.5	21	99.0	
$C_{27}H_{32}N_2O_3S$	Cinchonine *p*-xylene-2-sulfinate	$CHCl_3$	5	21	114.2	(903)
		$CHCl_3$	2.5	21	120.2	

* Calculated on weight of alkaloid.

Cinchonine, cinchonidine and their derivatives; cf. (866, 875, 876, 885.5, 1026, 1027, 1028, 1030, 1187, 1196, 1543.5, 1794, 1963, 2070, 2223, 2223.5)—*(Continued)*

Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{27}H_{32}N_2O_4S$	Cinchonine *p*-xylene-2-sulfonate	$CHCl_3$	5	21	97.2	(903)
		$CHCl_3$	2.5	21	103.8	
$C_{28}H_{28}N_2O_3$	Cinchonine phenylpropiolate	$CHCl_3$	4	23	86.00	(901)
		$CHCl_3$	1	23	100.0	
		H_2O	0.5	23	92.0	
$C_{28}H_{30}N_2O_3$	Cinchonine cinnamate	$CHCl_3$	4	23	107.0	(901)
		$CHCl_3$	1	23	121.50	
		H_2O	0.5	23	117.00	
$C_{28}H_{30}N_2O_5$	Cinchonine acetylsalicylate	$CHCl_3$	5	21	135.0	(901)
$C_{28}H_{31}N_3O_4$	Cinchonine acetylanthranilate	$CHCl_3$	5	21	125.8	(902)
		$CHCl_3$	2.5	21	141.2	
$C_{28}H_{32}N_2O_3$	Cinchonine di-β-phenylpropionate (other salts; *cf.* (1946))	$CHCl_3$	5	21	116.2	(902)
		$CHCl_3$	2.5	21	120.5	
$C_{28}H_{32}N_2O_3$	Cinchonine β-phenylpropionate	EtOH	0.5	23	222.0	(901)
		$CHCl_3$	4	23	116.25	
		$CHCl_3$	1	23	125.00	
		H_2O	0.5	23	98.00	
$C_{29}H_{30}Cl_2N_2O$	α-Naphthylcinchotoxine dihydrochloride	H_2O	0.21	15	49.6	(351)
$C_{29}H_{36}N_2O_4S$	Cinchonidine *dl-sec.*-butylbenzenesulfonate	MeOH	1	20	−7.34	(1088)
$C_{31}H_{32}N_2O_4S$	Cinchonine phenetylsulfinate	$CHCl_3$	5	21	101.2	(903)
		$CHCl_3$	2.5	21	104.2	
$C_{31}H_{32}N_2O_5S$	Cinchonine phenetylsulfonate	$CHCl_3$	5	21	98.1	(903)
		$CHCl_3$	2.5	21	105.4	
$C_{33}H_{32}N_2O_5$	Cinchonine benzoylsalicylate	$CHCl_3$	5	21	137.3	(901)
		$CHCl_3$	2.5	21	156.0	
$C_{33}H_{34}N_2O_5$	Cinchonine dibenzoate	$CHCl_3$	5	21	151.0	(902)
$C_{33}H_{34}N_3O_4$	Cinchonine benzoylanthranilate	$CHCl_3$	5	21	144.2	(902)
		$CHCl_3$	2.5	21	161.8	
$C_{33}H_{34}N_4O_5$	Cinchonine dianthranilate	$CHCl_3$	5	21	161.4	(902)
$C_{35}H_{38}N_2O_5$	Cinchonine diphenylacetate	$CHCl_3$	5	21	107.0	(902)
		$CHCl_3$	2.5	21	109.0	
$C_{37}H_{36}N_4O_5$	Cinchonine diacetylanthranilate	$CHCl_3$	5	21	111.3	(902)
$C_{38}H_{46}N_4O_6S$	Cinchonine sulfate	97% EtOH	10	15	189.45	(885.5)
$C_{38}H_{46}N_4O_6S$	Cinchonidine sulfate, anhydrous	1.294*N* H_2SO_4	3	19	153.0	(1658)
$C_{38}H_{46}N_4O_6S.6H_2O$	Hydrated	H_2O	1.06	15	−106.77	(1540)
		H_2O	2	15	−110.5	
$C_{38}H_{46}N_4O_6S.7H_2O$		1.294*N* H_2SO_4	3	19	132.2	
$C_{40}H_{46}N_4O_6$	Cinchonine oxalate	EtOH + $CHCl_3$	2.0	15	−98.7	(885.5)
$C_{47}H_{46}N_4O_7$	Cinchonine dibenzoylanthranilate	$CHCl_3$	5	21	113.8	(902)
	Quinine and isomerides ($C_{20}H_{24}N_2O_2$) and their derivatives					
$C_{19}H_{22}N_2O_2$	Apoquinine	97% EtOH	2	15	−178.1	(875); *cf.* (1261)
		3*N* HCl	2	15	−246.6	
$C_{19}H_{22}N_2O_2.2H_2O$	Apoquinidine	97% EtOH	2	15	155.3	(875)
		3*N* HCl	2	15	216.5	
$C_{19}H_{22}N_2O$	Apoquinamine	EtOH	2	15	0	(877); *cf.* (934)
		11*N* HCl	2	15	−30.0	
$C_{19}H_{24}N_2O_2$	Quinamine	EtOH	1.774	15	100.7	(1541); *cf.* (865, 871.5, 877)
		Et_2O	1.024	15	119.9	
		$CHCl_3$	2.235	15	93.3	
		C_6H_6	1.489	15	100.9	
$C_{19}H_{24}N_2O_2$	Quinamidine	97% EtOH	2	15	4.5	(877)
		97% EtOH	2	15	38.1	
$C_{19}H_{24}N_2O_2$	Conquinamine	EtOH	4.018	15	204.1	(1542, 1543); *cf.* (878)
		Et_2O	1.522	15	188.1	
		$CHCl_3$	2	15	184.5	(878)
		3*N* HCl	4	15	230.0	

Quinine and isomerides ($C_{20}H_{24}N_2O_2$) and their derivatives.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{19}H_{25}ClN_2O_2.H_2O$	Quinamine hydrochloride	H_2O	2	15	100.0	(877)
$C_{19}H_{25}BrN_2O_2.H_2O$	Quinamine hydrobromide	H_2O	4	15	88.2	
$C_{19}H_{25}IN_2O_2$	Quinamine hydroiodide	EtOH	2.310	16	95.8	(1541)
$C_{20}H_{22}N_2O_2$	Dehydroquinine	$CHCl_3$.EtOH	*2.1*	17	−179	(290)
$C_{20}H_{22}N_2O_2$	Quininone	EtOH	2.14	23	73.79*	(1755)
$C_{20}H_{23}Br_3N_2O$	Quinine tribromide (*a*) isomeride	MeOH		10	198	(620)
	(*b*) isomeride	$CHCl_3$		10	119	
$C_{20}H_{23}ClN_2O$	Quinine chloride	EtOH	1.90	15	61	(1756)
$C_{20}H_{23}ClN_2O$	Quinidine chloride	EtOH	1.943	15	35.25	
$C_{20}H_{23}ClN_2O_2$	Quininone hydrochloride	EtOH	1.93	14	58.67	(1755)
$C_{20}H_{24}N_2O$	Desoxyquinine, anhydrous	EtOH	2.252	20	−97.7	(1756)
	Hydrated	EtOH	2.021	15	−93.0	(1756)
$C_{20}H_{24}N_2O.H_2O$	Desoxyquinidine, anhydrous	EtOH	2.023	20	211.1	(1756)
	Hydrated	EtOH	2.254	15	191.9	
$C_{20}H_{24}N_2O_2$	Quinine	C_6H_6	0.61	17	−136	(1196); *cf.* (1945)
		PhMe	0.39	17	−127	
		$CHCl_3$	1.465	17	−117	
		EtOH	2.136	15	−158.2	(1756)
$C_{20}H_{24}N_2O_2$	α-Isoquinine	EtOH	1.0	18	−245	(163)
		EtOH	0.5	18	−248	
	β-Isoquinine	EtOH	0.5	18	−192.4	
		EtOH	1.0	18	−195.35	
		EtOH	2.0	18	−191.6	
$C_{20}H_{24}N_2O_2$	Quinidine (conquinine); *cf.* (867, 885.5, 1196, 2223)	C_6H_6	1.62	17	195.2	(1540)
		PhMe	1.62	17	206.2	(1612); *cf.* (885.5, 1540)
		$CHCl_3$	1.62	17	228.8	
		97% EtOH	*1.0*		233.6	
		90% EtOH	0.7735	15	243.5	
$C_{20}H_{24}N_2O_2$	Quinicine	$CHCl_3$	2	15	44.1	(866)
		$CHCl_3$			38.67	(934)
$C_{20}H_{24}N_2O_2$	Quinine isomeride	EtOH	0.9248		−237.89	(162)
		EtOH	0.9702		−181.67	
$C_{20}H_{24}N_2O_2$	Isoconquinine	97% EtOH	*1.394*		−9	(1612)
$C_{20}H_{24}N_2O_5S$	Quininesulfonic acid	3*N* HCl	2	15	−182.2	(888.5)
$C_{20}H_{25}ClN_2O_2$	Quinine hydrochloride	H_2O	1.54	17	−133.7	(1540)
		H_2O	1	15	−227.25	
		H_2O	3.97	21.8	−228.0	(1445)
		H_2O	3.82	85.1	−216.7	
		EtOH	1.54*	17	−138.0	
		1*N* HCl	7	15	−213.99	(885.5)
$C_{20}H_{25}ClN_2O_2.H_2O$	Quinidine hydrochloride	H_2O	2	15	195.97	(885.5); *cf.* (1540)
$C_{20}H_{25}N_3O_5.H_2O$	Quinidine nitrate	EtOH	2.17	17	232	(1540)
$C_{20}H_{26}Cl_2N_2O_2.H_2O$	Quinidine dihydrochloride	H_2O	2	15	250.3	(885.5)
$C_{20}H_{26}N_2O_2$	Hydroquinine	EtOH	2.4	20	−142.2	(1196); *cf.* (880.5, 886)
$C_{20}H_{26}N_2O_6S$	Quinine hydrogen sulfate	H_2O	4.22	15.9	−212.2	(1445)
		H_2O	4.09	7.85	−189.9	
$C_{20}H_{26}N_2O_6S.7H_2O$	Hydrated	80% EtOH	1	15	−154.5	(885.5)
		80% EtOH	3	15	−153.3	
$C_{21}H_{24}N_2O_4$	Acetylquininol	$CHCl_3$	1	22	−63.5	(1917)
$C_{21}H_{26}N_2O_4$	Quinine formate	H_2O	2.00	21	−141.1	(1145); *cf.* (1146)
$C_{22}H_{26}N_2O_3$	Acetylquinine	3*N* HCl	2	22.9	−120.8	(1917); *cf.* (881.5)
		$CHCl_3$	1	14.4	−30.9	
$C_{22}H_{26}N_2O_3$	Acetylquinidine	97% EtOH	2	15	127.6	(875)
		3*N* HCl	2	15	216.5	
$C_{23}H_{26}N_2O_4$	Diacetylapoquinine	3*N* HCl	2	15	−107.5	(875)
		EtOH	2		−61.8	

* Calculated on weight of alkaloid.

Quinine and isomerides ($C_{20}H_{24}N_2O_2$) and their derivatives.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{23}H_{26}N_2O_4$	Diacetylapoquinidine	97% EtOH	2	15	40.4	(875)
		3*N* HCl	2	15	78.4	
$C_{23}H_{28}N_2O_3$	Propionylquinine	3*N* HCl	2	15	108.8	(875)
$C_{26}H_{26}N_2O_4$	Benzoylquininal	$CHCl_3$	1	22.4	79.4	(1917)
$C_{27}H_{28}N_2O_3$	Benzoylquinine	EtOH	1	19.2	119.9	(1917)
		$CHCl_3$	1	16.6	118.1	
$C_{39}H_{46}N_4O_4$	Cupreinequinine (homoquinine)	EtOH	5		−158	(935)
$C_{30}H_{38}N_2O_5S$	Quinine *dl-sec.*-butylbenzenesulfonate	MeOH	1.24	20	−10.5	(1088)
$C_{40}H_{50}N_4O_8S$	Quinine sulfate; *cf.* (268, 875, 885.5, 1540, 1543)	80% EtOH	2	15	−162.95	(396)
		60% EtOH	2	15	−166.36	
		1.249*N* H_2SO_4	3	19	−237.7	(1658)
	Heptahydrate	1.249*N* H_2SO_4			−203.3	(1658)
	Quinidine sulfate heptahydrate	H_2O	*1.0*		179.5	(1612); *cf.* (885.5, 1540)
	Isoconquinine hydrogen sulfate	H_2O	*2.464*		10.2	(1612)
	Quinidine hydrogen sulfate dihydrate	H_2O	*2.0*		210.5	(1612); *cf.* 885.5, 1540)
	Isoconquinine sulfate	H_2O	*1.406*		−35.5	(1612)
$C_{40}H_{52}N_4O_8.H_2O$	Nitrocamphorquinine	EtOH	*2.72*		45.9	(276)
$C_{42}H_{50}N_4O_8.3H_2O$	Quinine oxalate	EtOH	1.54*	17	−131.4	(885.5)
$C_{42}H_{50}N_4O_8$	Quinicine oxalate	H_2O	2		10	(1613)
$C_{42}H_{50}N_4O_8.9H_2O$	Hydrated	H_2O	2	15	9.54	(866)
		2*M* H_2SO_4	2	15	15.54	(866)
$C_{42}H_{50}N_4O_8$	Isoquinicine oxalate	H_2O	2		−8.59	(1613)
		H_2O	2		−9.79	
Strychnine, its isomerides and derivatives						
$C_{19}H_{18}N_2O_3$	Strychninolone	AcOH	*2.66*	20	−112.4	(1214)
$C_{21}H_{20}N_2O_6$	Strychninonic acid	0.1*N* NaOH	*7.874*	20	−43.3	(1204)
$C_{21}H_{21}N_3O_6$	Strychninonic acid oxime	0.1*N* NaOH	*3.91*	20	119	(1214)
$C_{21}H_{22}N_2O_2$	Strychnine; *cf.* (920, 1945, 1946, 1995, 2053, 2223)	$CHCl_3$	4		−130	(1539)
		$CHCl_3$	2.5		−137.7	
		$CHCl_3$	1.5		−140.7	
		EtOH	0.91		−128	
	Isostrychnine	EtOH	3.4	17.5	6.77	(1533); *cf.* (1640)
$C_{21}H_{22}N_2O_3$	Strychnine oxide	H_2O	1.86		−1.75	(1644)
$C_{21}H_{22}N_2O_5S.2H_2O$	Strychninesulfonic acid	0.1*N* NaOH	*2.02*	20	−138	(1215)
$C_{21}H_{22}N_2O_5S.3H_2O$	Strychninesulfonic acid	0.1*N* NaOH	*2.02*	20	−163.3	(1215)
$C_{21}H_{22}N_2O_6$	Dihydrostrychninonic acid	0.1*N* NaOH	3.5	20	4.3	(1204)
$C_{21}H_{24}N_2O_6S.2H_2O$	Strychninesulfonic acid, IV hydrate	H_2O	2.010	20	18.3	(1217)
$C_{31}H_{36}N_2O_5S$	Strychnine *dl-sec.*-butylbenzenesulfonate	MeOH	0.846	20	0	(1088)
$C_{61}H_{62}N_2O_{10}S_2Si_2$	Strychnine dibenzylpropylethylsilicanedisulfonate ($Si.C_2H_5.C_3H_8(CH_2.C_6H_4.SO_2.OH)_2C_{21}H_{22}N_2O_2$)	98% MeOH	2.465		−15.21	(281)
		64% MeOH	2.119		−22.4	(281)
Brucine ($C_{23}H_{26}N_2O_4$) and its derivatives						
$C_{21}H_{22}N_2O_5$	Brucinolone	AcOH	4.78	22	−34.7	(1367); *cf.* (1207, 1213, 1216)
		AcOH	2.38	22	−32.6	
		AcOH	4.56	22	−37.2	
		AcOH	3.93	22	−37.7	
$C_{21}H_{22}N_2O_5$	Isobrucinolone	AcOH	1.1	24	26.7	(1207)
$C_{23}H_{22}N_2O_8Na_2$	Sodium brucinonate	H_2O	*4.27**	20	−48.5	(1204)
$C_{23}H_{24}N_2O_7$	Trihydroxydehydrobrucine	37.6% HCl	*3.73*	20	87.4	(1212)
$C_{23}H_{24}N_2O_8Na_2$	Sodium dihydrobrucinonate	H_2O	16.1*	20	−14.8	(1204)
$C_{23}H_{25}N_3O_8$	Brucinonic acid oxime	AcOH	*2.68*	17	81.7	(1209)
		0.1*N* NaOH	4.71	20	128.2	(1216)
$C_{23}H_{26}N_2O_4$	Brucine	EtOH	5.4		−85	(1539); *cf.* (2053)
		$CHCl_3$	4.9		−119	
		$CHCl_3$	1.9		−127	

* Calculated on weight of alkaloid.

Brucine ($C_{23}H_{26}N_2O_4$) and its derivatives.—(Continued)

Formula	Name	Solvent	*d*, *C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{23}H_{26}N_2O_4$	Allobrucine	$CHCl_3$	4.54		−112.8	(1464)
$C_{23}H_{26}N_2O_5$	Brucine oxide	H_2O	3.05	28	−1.63	(1643)
$C_{23}H_{26}N_2O_7$	Trioxybrucine	AcOH	4.33	20	5.66	(1212)
$C_{23}H_{26}N_2O_7S$	Brucine sulfonic acid I	0.1*N* NaOH	*4.48*	20	−242	(1211)
	II	0.1*N* NaOH	*2.3*	20	29.2	
	III	0.1*N* NaOH	*2.36*	20	156.8	
$C_{23}H_{26}N_2O_8$	Brucinolic acid	0.1*N* NaOH	4.56	20	−22	(1216)
$C_{23}H_{27}ClN_2O_5$	Brucine hydrochloride	H_2O	0.595	28	−13.95	(1643)
$C_{23}H_{27}N_3O_8$	Brucine nitrate	H_2O	0.879	30	−11.36	(1643)
$C_{24}H_{27}N_5O_8.3H_2O$	Brucinonic acid semicarbazone	0.1*N* NaOH	5.13	20	252	(1216)
$C_{25}H_{28}N_2O_9$	Diacetyldihydroxydihydrobrucinoline-*b*	AcOH	*1.95*	20	−149.2	(1210)
$C_{26}H_{34}N_2O_7$	Methylbrucine acetate	H_2O	4.01	20	−9.97	(1465)
$C_{27}H_{28}N_2O_8$	Brucine hydrogen acetylenedicarboxylate	$CHCl_3$	0.47	27	−5.26	(903)
		EtOH	0.47	27	−3.22	
		H_2O	3.73	25	−15.02	
		H_2O	0.93	25	−18.77	
$C_{27}H_{30}N_2O_8$	Brucine hydrogen fumarate	EtOH	0.47	23	10.69	(903)
		H_2O	1.870	24	−24.86	
		H_2O	0.94	24	−25.14	
$C_{27}H_{30}N_2O_8$	Brucine hydrogen maleate	$CHCl_3$	0.49	25	6.12	(903)
		H_2O	0.98	25	−24.49	
$C_{27}H_{32}N_2O_8$	Brucine hydrogen succinate	$CHCl_3$	0.47	25	−23.40	(903)
		EtOH	0.47	25	−31.92	
		H_2O	3.74	24	−27.81	
		H_2O	0.94	24	−24.60	
$C_{27}H_{36}N_2O_7$	Dimethylbrucine acetate	H_2O	4.2	20	−7.14	(1465)
$C_{28}H_{26}N_2O_6$	Benzoylisobrucinolone	AcOH	*2.00*	16	99	(1210)
$C_{28}H_{26}N_2O_6$	Benzoylbrucinolone-*b*	AcOH	*2.93*	16	−148	(1210)
$C_{29}H_{32}N_2O_6S$	Brucine benzenesulfinate	$CHCl_3$	5	22	−19.8	(903)
$C_{29}H_{32}N_2O_7S$	Brucine benzenesulfonate	$CHCl_3$	5	22	−16.1	
$C_{29}H_{36}N_2O_{10}$	Brucine anhydrotalonate	EtOH	2.5	20	−12.45	(1221)
$C_{29}H_{36}N_2O_{10}$	Brucine anhydrogalactonate	EtOH	2.5	20	−9.23	(1221)
$C_{29}H_{36}N_2O_{10}$	Brucine lyxohexosamate (deaminized)	EtOH	2.5	25	−11.96	(1221)
$C_{30}H_{32}N_2O_6$	Brucine benzoate	$CHCl_3$	5	21	−25.4	(902)
		$CHCl_3$	2.5	21	−25.0	
$C_{30}H_{32}N_2O_7$	Brucine salicylate	$CHCl_3$	5	21	14.2	(902)
$C_{30}H_{33}N_3O_6$	Brucine anthranilate	$CHCl_3$	5	21	−9.0	(902)
$C_{30}H_{34}N_2O_6S$	Brucine *p*-toluenesulfinate	$CHCl_3$	5	21	−15.2	(903)
$C_{30}H_{34}N_2O_7S$	Brucine *p*-toluenesulfonate	$CHCl_3$	5	21	−12.5	
$C_{31}H_{34}N_2O_6$	Brucine phenylacetate	$CHCl_3$	5	21	−30.5	(902)
		$CHCl_3$	2.5	21	−32.2	
$C_{31}H_{36}N_2O_6S$	Brucine *p*-xylene-2-sulfinate	$CHCl_3$	5	21	−14.0	(903)
$C_{31}H_{36}N_2O_7S$	Brucine *p*-xylene-2-sulfonate	$CHCl_3$	5	21	−15.5	
$C_{31}H_{36}N_2O_7S$	Brucine phenetylsulfinate	$CHCl_3$		22	−20.3	(903)
$C_{31}H_{36}N_2O_8S$	Brucine phenetylsulfonate	$CHCl_3$		22	−14.1	(903)
$C_{32}H_{32}N_2O_3$	Brucine phenylpropiolate	$CHCl_3$	3.75		3.33	(901)
		$CHCl_3$	0.94		2.67	
		H_2O	0.94		−22.94	
$C_{32}H_{34}N_2O_4$	Brucine cinnamate	$CHCl_3$	3.64	18	−11.68	(901)
		$CHCl_3$	0.91	18	−17.58	
		$CHCl_3$	0.91		−18.68	
$C_{32}H_{34}N_2O_8$	Brucine acetylsalicylate	$CHCl_3$	5	21	15.1	(902)
$C_{32}H_{35}N_3O_7$	Brucine acetylanthranilate	$CHCl_3$	5	21	5.2	(902)
$C_{32}H_{36}N_2O_6$	Brucine *β*-phenylpropionate	$CHCl_3$	5	21	−38.2	(902)
		$CHCl_3$	2.5	21	−38.5	
		$CHCl_3$	3.64	19	−38.19	(901)
		$CHCl_3$	0.91	19	−38.46	
		H_2O	0.91	19	−25.27	
$C_{32}H_{40}N_2O_6$	Brucine 1-methylcyclohexylidene acetate, *see*	p. 458				
$C_{37}H_{36}N_2O_8$	Brucine benzoylsalicylate	$CHCl_3$	5	21	±0.1	(902)
$C_{37}H_{37}N_3O_7$	Brucine benzoylanthranilate	$CHCl_3$	5	21	24.6	(902)
$C_{50}H_{56}N_4O_{12}$	Brucine fumarate	$CHCl_3$	1.79	24	−61.45	(903)
		H_2O	1.79	22	−34.91	

Brucine ($C_{23}H_{26}N_2O_4$) and its derivatives.—(Continued)

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_{50}H_{56}N_4O_{12}$	Brucine maleate	$CHCl_3$	1.74	24	−63.22	(903)
		$CHCl_3$	0.87	24	−61.51	
		H_2O	3.48	23	−44.97	
		H_2O	0.87	23	−41.96	
$C_{50}H_{58}N_4O_{12}$	Brucine succinate	$CHCl_3$	4	25	−68.75	(903)
		$CHCl_3$	1	25	−75.50	
		H_2O	4	25	−33.75	

Other alkaloids, their derivatives and other substances

Formula	Name	Solvent	d, C or %	t, °C	$[\alpha]_D$	Lit.
$C_8H_{15}N$	α-Coniceine	EtOH	1.66	15	18.4	(1266)
$C_9H_{11}BrN_2O_6$	Bromouridine	H_2O	10.05	21	−15.4	(1231)
$C_9H_{13}N_3O_5$	Cytidine	H_2O	10.0	21	29.6	(1231)
$C_9H_{14}N_2O$	α-Oximino-β-vinylquinuclidine	EtOH	2.005	16	113	(1756)
$C_9H_{14}N_2O_6$	Dihydrouridine	H_2O	4.028		39.1	(1231)
$C_9H_{15}N_5O_6$	Carnosine nitrate	H_2O	*7.60*	19.5	22.2	(764)
$C_{10}H_{13}NO_3$	Ratanhine	11% HCl	2.013	19	−18.6	(732)
$C_{11}H_{14}N_2O$	Cytisine	H_2O	2	12	−120	(1655)
		$CHCl_3$	2	12	−100.42	
		90% EtOH	2	12	−100.42	(1768)
		$CHCl_3$	2	12	−65.42	
$C_{11}H_{15}N_3O_4$	Cytisine nitrate	H_2O	5	11	−90.17	(1655)
$C_{11}H_{18}N_2$	Daucine	Et_2O			7.74	(1641, 1642)
$C_{11}H_{20}Cl_2N_2$	Tetrahydrodesoxycytisine dihydrochloride	H_2O	8		−10.25	(672)
		H_2O	1.128		−2.22	(1710)
$C_{12}H_{16}N_2O$	Methylcytisine	H_2O	2	18.5	−224.7	(1768)
		H_2O	50	18.5	−219.7	
		EtOH	5	18.5	−170.2	
		EtOH	30	18.5	−154.9	
		$CHCl_3$	5	19.5	−163.33	
		$CHCl_3$	40	19.5	−141.6	
		MeOH	5		−198	
		MeOH	40		−164.4	
$C_{13}H_{18}N_2O$	Eseroline	MeOH	1.368		−107.2	(1856)
$C_{15}H_{15}BrO_6$	α-Bromopicrotoxinin	$CHCl_3$	0.9520	17	−69.9	(926)
	β-Bromopicrotoxinin	$CHCl_3$	0.9608	17	−129.1	
$C_{15}H_{16}O_6$	Picrotoxinin	EtOH	4.279	17	4.40	(926); *cf.* (1948)
		Me_2CO	8.131	17	4.5	
	Prepd. from α-bromopicrotoxinin	Me_2CO	7.576	17	3.49	
$C_{15}H_{17}NO_3$	Benzoyl-*d*-orseine	50% EtOH	1.17		3.5	(2048)
$C_{15}H_{18}O_7$	Picrotin	EtOH	2.07	16	−69.64	(1948)
$C_{15}H_{21}N_3O_2$	Physostigmine (from Calabar beans)	$CHCl_3$	1.329		−75.8	(1855)
	Commercial	$CHCl_3$	1.531		−75.8	
$C_{15}H_{26}N_2$	Lupinidine		1.023	20	−5.96	(2188)
		99% EtOH	14.20	21	−16.41	
$C_{16}H_{17}NO_4$	Narcissine (from *Narcissus pseudonarcissus*)	EtOH	0.166	10	−95.8	(439)
$C_{16}H_{18}N_2O_3$	Carpiline	EtOH	*1.014*	20	24.0	(1191)
$C_{16}H_{19}ClN_2O_3$	Carpiline hydrochloride	EtOH	*1.212*	22	15.4	(1191)
$C_{16}H_{24}O_4$	Bufotalin	$CHCl_3$	6.8	20	5.4	(2176)
$C_{16}H_{27}IN_2O$	*d*-Lupanine methiodide	H_2O	3.819	18	51.48	(99)
		H_2O	5.633	19	51.35	
$C_{17}H_{17}NO_3$	Pukateine	EtOH	0.6	15	−220	(63)
$C_{17}H_{19}NO_3$	Isobebeerine	Py	*4.24*	20	68.4	(1889)
$C_{17}H_{21}NO_4$	Scopolamine; *cf.* (697, 891, 2181, 2182)	EtOH	*2.65*	15	−13.7	(891)
		H_2O			−14.97	(224.3)
$C_{17}H_{22}BrNO_4$	Scopolamine anhydride hydrobromide	H_2O	4.5	18	−26.0	(2186)
$C_{17}H_{24}N_2O_5$	Casimeroedine	1% HCl	2.099		−36.5	(1695)
$C_{18}H_{19}NO_3$	Oxycanthine	EtOH.$CHCl_3$	4	15	131.6	(884, 891)
$C_{18}H_{20}ClNO_3.2H_2O$	Hydrochloride	H_2O	2	15	163.6	(884, 891)
$C_{18}H_{21}NO_3$	Bebeerine	EtOH	*1.6*	25	297	(1886)
$C_{18}H_{21}NO_4$	Chondrodine	EtOH	1.0	20	−75	(1888)
$C_{19}H_{19}NO_4$	Bulbocapnine	$CHCl_3$	4.48	16	237.1	(673)
$C_{19}H_{22}N_2O_2.2H_2O$	Cupreine	EtOH	1.78	17	−173.3	(1545)
$C_{19}H_{23}ClN_2O_2$	Cupreine hydrochloride	EtOH	1.42	17	−167.3	(1545)
		H_2O	0.871	17	−154.8	

Other alkaloids, their derivatives and other substances.—(*Continued*)

Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{19}H_{24}Cl_2N_2O_2.2H_2O$	Cupreine dihydrochloride	H_2O	17.28	17	−191.1	(1545)
		H_2O	1.19	17	−211.0	
$C_{20}H_{21}NO_4$	*d*-Bulbocapnine methyl ether	$CHCl_3$	1.570	20	247.2	(705)
	l-Bulbocapnine methyl ether	$CHCl_3$	1.728	20	−246.5	
$C_{20}H_{22}INO_4$	Bulbocapnine	EtOH	1.4936	20	173.8	(705)
$C_{20}H_{22}N_2O_2$	Gelsemine	$CHCl_3$	2.033		15.9	(1452); *cf.* (1455)
$C_{20}H_{23}ClN_2O_2$	Hydrochloride	H_2O	1.550		2.6	(1452, 1455)
$C_{20}H_{22}N_2O_2$	Gelsemine, isomeride of	$CHCl_3$	0.596		25.2	(1455)
$C_{20}H_{23}ClN_2O_2$	Chloroisoapogelsemine	$CHCl_3$	1.224		74.2	(1455)
$C_{20}H_{23}NO_4$	Corypalmine	$CHCl_3$	*0.38*	16	280	(1977)
$C_{20}H_{23}N_3O_2$	Pheneserine	EtOH			−80	(1659)
$C_{20}H_{23}N_3O_3$	Phenogeneserine	$CHCl_3$			−125.5	(1659)
$C_{20}H_{24}N_2O_3$	Isoapogelsemine	Py	2.406		16.6	(1455)
$C_{20}H_{25}ClN_2O_3.H_2O$	Hydrochloride	H_2O	1.045		27.1	(1455)
	Apogelsemine hydrochloride	H_2O	2.071		18.9	
$C_{21}H_{18}N_2$	*l*-Isoamarine	EtOH	1.49		−28.94*	(1972)
$C_{21}H_{21}NO_5$	Corycavamine	$CHCl_3$	*2.23*	20	166.6	(700)
$C_{21}H_{23}NO_4$	*d*-Corydine	$CHCl_3$	1.592	20	206.2	(702)
$C_{21}H_{23}NO_4$	Isocorydine	$CHCl_3$	1.60	20	195.3	(702)
$C_{21}H_{23}NO_4$	*β*-Bebirine	Py	*1.70*	21	−24.7	(441)
		EtOH	*1.64*	21	28.6	
	Isobebirine	Py	*1.73*	22	−47.7	
$C_{21}H_{24}INO_4$	Bulbocapnine methyl ether methiodide	EtOH	1.48	20	163.7	(705)
$C_{21}H_{25}IN_2O_2$	Gelsemine methiodide	H_2O	1.025		8.9	(1455)
$C_{21}H_{25}NO_4$	Corybulbine	$CHCl_3$	1.41	20	303.3	(704)
$C_{21}H_{25}NO_4$	Isocorybulbine	$CHCl_3$	1.045	20	299.8	(700)
$C_{21}H_{25}NO_4$	*d*-Tetrahydropalmatine	EtOH	*1.93*	17	292.5	(1977)
$C_{21}H_{26}IN_3O_2$	Pheneserine methiodide	EtOH			−92.8	(1659)
$C_{23}H_{23}NO_{10}$	Hydrastine acid oxalate	$CHCl_3$	2.0		8.22	
$C_{42}H_{44}N_2O_{16}S$	Hydrastine sulfate	$CHCl_3$	2.0		7.44	(268)
$C_{21}H_{26}N_2O_2$	Cupreine ethyl ester	EtOH			−169.4	(749)
$C_{21}H_{26}N_2O_3$	Yohimbine (quebrachine)	EtOH	2	15	62.5	(879)
		97% $CHCl_3$	2	15	18.6	
$C_{21}H_{27}IN_2O_3$	Apogelsemine methiodide	H_2O	1.335		12.4	(1455)
	Isoapogelsemine methiodide	H_2O	1.630		28.1	
$C_{22}H_{23}NO_7$	Narcotine	EtOH	0.74	22.5	−185.0	(1799)
		97% $CHCl_3$	2.5	22.5	−207.35	
		C_6H_6	*1.59*		−229	(885.5)
$C_{22}H_{24}N_2O_3$	Acetylgelsemine	$CHCl_3$	1.745		23.9	(1455)
$C_{22}H_{25}ClN_2O_3$	Chloroacetylisoapogelsemine	$CHCl_3$	1.020		142.9	(1455)
$C_{22}H_{26}ClNO_4$	*d*-*β*-Canadine ethylchloride	50% EtOH	*0.91*	20	138.5	(2080)
$C_{22}H_{26}ClNO_4.2H_2O$	*l*-*α*-Canadine ethylchloride	50% EtOH	*0.75*	20	−127.3	(2080)
$C_{22}H_{26}INO_4$	*d*-*β*-Canadine ethiodide	50% EtOH	*1.01*	20	115	(2080)
$C_{22}H_{26}INO_4.1.5H_2O$	*l*-*α*-Canadine ethiodide	50% EtOH	*1.00*	20	−92.2	(2080)
$C_{22}H_{26}N_2O_7$	*d*-*β*-Canadine ethylnitrate	50% EtOH	*0.99*	20	130.7	(2080)
$C_{22}H_{26}N_2O_7.1.5H_2O$	*l*-*α*-Canadine ethylnitrate	50% EtOH	*1.00*	20	−121	(2080)
$C_{22}H_{27}NO_4$	Corydaline	$CHCl_3$	6.55	16	300.1	(673)
$C_{22}H_{28}ClNO_4$	Dimethylcorytuberine methochloride	H_2O	1.0104		197.40	(702)
$C_{22}H_{28}N_2O_2$	Aspidospermatine	97% EtOH	2	15	−72.3	(879)
$C_{22}H_{28}N_2O_4.H_2O$	Echitamine	97% EtOH	2	15	−28.8	(873); *cf.* (830)
$C_{22}H_{30}N_2O_2$	Aspidospermine	97% EtOH	2	15	−100.2	(879)
		$CHCl_3$	2	15	−83.6	
		3*N* HCl	2	15	−61.6	
		10*N* HCl	2	15	−62.2	
$C_{22}H_{31}NO_2$	Atisine	EtOH			−19.6	(1012)
$C_{22}H_{32}ClNO_2$	Atisine hydrochloride	H_2O			18.46	
$C_{22}H_{32}BrNO_2$	Atisine hydrobromide	H_2O			24.3	
$C_{22}H_{32}INO_2$	Atisine hydroiodide	H_2O			27.4	

* Mutarotation.

Other alkaloids, their derivatives and other substances.—(Continued)

Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{23}H_{26}N_2O_4.2H_2O$	Cusonine	Et_2O	2	15	−26.8	(868, 881)
		EtOH	2	15	−54.3	
		3*N* HCl	0.5	15	−71.8	
	Concusonine	EtOH	2	15	36.8	(881); *cf.* (882)
$C_{23}H_{26}N_2O_4$	Acrine	Et_2O	1	15	−94.7	(868)
		EtOH	1	15	−54.1	(868)
$C_{23}H_{29}NO_9$	Oxonitine	$CHCl_3$	0.508	16	−62	(266)
$C_{24}H_{28}ClN_3O$	Quaternary isocalycanthine chloride	H_2O	0.541	24	246.8	(738)
$C_{24}H_{28}IN_3O$	Quaternary isocalycanthine iodide	EtOH	0.3264	23.5	189.9	(738)
$C_{24}H_{29}NO_7$	α-Triacetylhydroxyisoberberine	Py	1.544	20	68.1	(1890)
$C_{24}H_{38}ClNO_9$	Pyroaconine hydrochloride	H_2O	1.96	15	−102.07	(400)
$C_{24}H_{29}ClN_2O_5$	Diacetylapogelsemine hydrochloride	H_2O	1.075		21.7	(1455)
	Diacetylisoapogelsemine hydrochloride	H_2O	1.152		24.6	
$C_{25}H_{30}Cl_2N_2O$	Phenylcinchotoxol dihydrochloride	H_2O	0.474	15	21.09	(351)
$C_{25}H_{32}BrNO_7S$	Benzoyl-*d*-oscine *d*-bromocamphorsulfonate	H_2O	2.046		52.1	(2048)
$C_{25}H_{33}NO_7S$	Benzoyloscine *d*-camphorsulfonate	H_2O	2.113		10.3	(2048)
$C_{25}H_{40}O_{10}$	Lepranthin	$CHCl_3$		17	71	(2243)
$C_{25}H_{41}NO_7$	Bikhaconine	EtOH	2.44	22	33.85	(399)
$C_{25}H_{41}NO_8$	Indaconine	H_2O	1.82	22	38.20	(399)
		EtOH	2.8	22	38.18	
$C_{25}H_{41}NO_9$	Aconine	H_2O			23.0	(268)
$C_{26}H_{41}NO_{11}$	Aconine	H_2O	*3.534*	15	23	(403)
$C_{26}H_{42}ClNO_{11}$	Aconine hydrochloride	H_2O	*5.75*	15	−771	(401); *cf.* (400.5)
$C_{25}H_{42}N_2O_{10}.2H_2O$	Bikhaconine nitrate	H_2O	2.03	20	15.38	(399)
$C_{26}H_{23}NO_5$	Monobenzoylbulbocapnine	$CHCl_3$	1.572	20	92.7	(705)
$C_{26}H_{25}NO_5$	Monobenzoylcorytuberine	$CHCl_3$	0.9916	20	151.5	(702)
$C_{26}H_{28}N_2O_2$	Hydrocinchonicine	EtOH abs.	6.17	23	8.8	(1045)
$C_{27}H_{26}INO_5$	Monobenzoylbulbocapnine methiodide	$CHCl_3$	1.6	20	28.1	(705)
$C_{27}H_{28}N_4O_3$	Dipheneserine	$CHCl_3$			−244	(1659)
$C_{28}H_{28}N_2O_6$	Acetyltrimethylbrasilin	AcOH	1.00	20	128.23	(863)
$C_{29}H_{36}N_2O_4$	Emetamine	$CHCl_3$	6.14		11.2	(1752)
		$CHCl_3$	4.28		9.9	
		EtOH	2.11		12.3	
$C_{29}H_{38}Br_2N_2O_4.7H_2O$	Dihydrobromide	H_2O	8.04		−24.3	(1752)
		H_2O	4.16		−22	
$C_{29}H_{38}N_2O_4$	*o*-Methylpsychotrine	EtOH	3.88		43.9	(1752)
		EtOH	2.08		46.1	
$C_{29}H_{40}N_2O_8S.7H_2O$	Sulfate	H_2O	8.06		44.4	(1752)
$C_{29}H_{40}N_2O_8S.H_2O$		H_2O	4.19		52.7	(1752)
$C_{29}H_{40}Br_2N_2O_4$	Dihydrobromide	H_2O	1.65		48.0	(1752)
$C_{31}H_{40}N_2O_8.3.5H_2O$	Oxalate	H_2O	4.27		41.9	(1752)
$C_{29}H_{40}N_2O_4$	Isoemetine	$CHCl_3$	3.51		−47.4	(1752)
$C_{29}H_{42}Cl_2N_2O_4$	Dihydrochloride	H_2O	15.07		−15.6	(1752)
		H_2O	8.13		−5.3	
		H_2O	4.09		4.6	
		H_2O	2.26		7.7	
		H_2O	0.91		12.7	
$C_{29}H_{42}Br_2N_2O_4$	Dihydrobromide	H_2O	4.153		6.5	(1752)
			1.989		10.5	
$C_{33}H_{40}N_2O_{12}$	Hydrogen oxalate		8.019		1.6	(1752)
			3.856		6.5	
			2.958		8.5	
			1.454		11.3	
$C_{30}H_{42}N_2O_4$	*N*-Methylisoemetine	$CHCl_3$	2.55		−50.0	(1753)
$C_{30}H_{42}N_2O_4$	*N*-Methylemetine	$CHCl_3$	3.83		−52.6	(1752)
		$CHCl_3$	4.7		−53.2	
$C_{30}H_{44}N_2O_8S.3H_2O$	Sulfate	H_2O	4.37		7.7	(1752)
$C_{30}H_{50}N_4O_{19}$	Chitin	HCl (concd.)			−14.1	(960)
$C_{31}H_{37}NO_{10}S$	Hydrastine *d*-camphorsulfonate	$CHCl_3$			156	(268)
	dl-Camphorsulfonate	$CHCl_3$			128	
$C_{31}H_{41}NO_{10}$	Pyroaconitine	H_2O	1.121	15	−90.99	(400)
$C_{31}H_{42}BrNO_{10}$	Hydrobromide	H_2O	2.136	15	−46.8	(400)

Other alkaloids, their derivatives and other substances.—(Continued)

Formula	Name	Solvent	*d, C* or %	*t*, °C	$[\alpha]_D$	Lit.
$C_{32}H_{31}NO_{11}$	α-Opianlactylnarcotine	$CHCl_3$	4.012	12	−94.73	(671)
	β-Opianlactylnarcotine	$CHCl_3$	4.439	12.5	−103.6	
$C_{32}H_{43}NO_8$	Pyroindaconitine	EtOH	1.62	20	91.91	(399)
$C_{32}H_{44}BrNO_8$	Pyroindaconitine hydrobromide	H_2O	0.99	20	54.71	(399)
$C_{32}H_{45}NO_9$	Indobenzaconine	EtOH	2.7	22	33.58	(399)
$C_{33}H_{45}NO_{12}$	Aconitine	EtOH	*3.726*	23	11.01	(402); *cf.* (1017)
$C_{33}H_{46}BrNO_{12}$	Aconitine hydrobromide	H_2O	*1.95*	20	−30.47	(402)
$C_{32}H_{46}ClNO_9$	Indobenzaconine hydrochloride	H_2O	3.78	25	−7.8	(399)
$C_{32}H_{48}I_2N_2O_4$	α-*N*-Methylemetine dimethiodide	H_2O	3.99		−2.3	(1753)
		H_2O	1.99		−4.5	
$C_{32}H_{48}Cl_2N_2O_4$	β-*N*-Methylemetine dimethochloride	H_2O	0.844		68.1	(1753)
$C_{32}H_{48}I_2N_2O_4.H_2O$	*N*-Methylisoemetine dimethiodide	H_2O	0.324		92.6	(1753)
$C_{33}H_{40}N_2O_{12}$	Emetamine hydrogen oxalate	H_2O	3.92		−6.0	(1752)
$C_{33}H_{45}NO_{12}$	Isoaconitine (napelline)	EtOH	7.86	15	4.48	(401)
$C_{33}H_{46}ClNO_{12}$	Isoaconitine hydrochloride	H_2O	1	15	−28.74	(401)
$C_{33}H_{46}BrNO_{12}$	Isoaconitine hydrobromide	H_2O	1	15	−30.47	(401)
$C_{33}H_{46}INO_{12}$	Isoaconitine hydroiodide	H_2O	1	15	−26.94	(401)
$C_{34}H_{47}NO_{10}$	Indaconitine	EtOH	2.28	21	18.72	(399)
$C_{34}H_{48}BrNO_{10}$	Indaconitine hydrobromide	H_2O	2.99		−17.27	(399)
$C_{34}H_{48}ClNO_{10}$	Indaconitine hydrochloride	H_2O	1.89	20	−35.45	(399)
$C_{34}H_{49}NO_{10}$	Veratroylbikhaconine	EtOH	2.79	20	29.9	(399)
$C_{35}H_{39}N_5O_5$	Ergotinine	EtOH	*0.257*	10	338	(88)
$C_{36}H_{42}N_2O_5$	*N*-Benzoyl-*O*-methylpsychotrine	$CHCl_3$	2.39		39.6	(1752)
$C_{36}H_{44}N_2O_5$	Benzoylisoemetine	$CHCl_3$	2.12		48.9	(1752)
	Benzoylemetine	$CHCl_3$	2.37		−62.3	
$C_{36}H_{46}N_2O_{10}$	Lycoaconitine	EtOH	9.30	20	42.47	(1905)
$C_{36}H_{46}N_2O_{10}$	Myoctonine	EtOH	10.27	20	44.79	(1905)
$C_{36}H_{51}NO_{11}$	Bikhaconitine	EtOH	2.609	20	12.21	(399)
$C_{36}H_{52}BrNO_{11}$	Bikhaconitine hydrobromide	H_2O	3.25	16	−12.42	(399)
$C_{36}H_{52}ClNO_{11}$	Bikhaconitine hydrochloride	H_2O	3.48	20	−8.86	(399)
$C_{45}H_{46}N_2O_{14}$	Methylenedinarcotine	$CHCl_3$	4.348		−93.4	(671)
$C_{47}H_{60}O_{29}$	Gentiacaulin	H_2O	1.82		−63.8	(246)

LITERATURE

(For a key to the periodicals see end of volume)

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(40) Armstrong and Lowry, *4*, **81**: 1441; 02. (41) Armstrong and Lowry, *4*, **81**: 1462; 02. (42) Armstrong and Lowry, *4*, **81**: 1469; 02. (43) Armstrong and Pope, *4*, **59**: 315; 91. (44) Armstrong and Robertson, *4*, **87**: 1272; 05. (45) Armstrong and Walker, *5*, **90**: 375; 14. (46) Arnaud, *34*, **93**: 593; 81. (46.5) Arnaud, *34*, **97**: 174; 83. (47) Arnaud, *34*, **107**: 1162; 88. (48) Arndtsen, *6*, **54**: 403; 58. (49) Arndtsen, *8*, **105**: 312; 58.

(50) Arth, *6*, **7**: 433; 86. (51) von Arx, *Thesis*, Zürich, 1919. *10*, **5**: 727; 25. (52) Asahina, *293*, **245**: 325; 07. (53) Asahina, *25*, **45**: 2363; 12. (54) Asahina, *25*, **46**: 1775; 13. (55) Asahina and Momoya, *293*, **252**: 56; 14. (56) Asahina and Sugii, *293*, **251**: 357; 13. (57) Aschan, *426*, **21**: No. 5; 95. (58) Aschan, *25*, **28**: 16; 95. (59) Aschan, *25*, **40**: 2750; 07.

(60) Aschan, *13*, **398**: 299; 12. (61) Aschan, *13*, **410**: 222; 15. (62) Aschan, *13*, **410**: 240; 15. (63) Aston, *4*, **97**: 1381; 10. (64) Atkinson and Yoshida, *4*, **41**: 49; 82. (65) Atterburg, *25*, **10**: 1202; 77. (66) Aubry, *49*, **10**: 202; 14. (66.5) Auerbach and Krüger, *279*, **46**: 97; 23. (67) Austerweil and Cochin, *34*, **150**: 1693; 10. (68) Backer and de Boer, *64P*, **26**: 79; 23. (69) Backer and de Boer, *70*, **43**: 297; 24.

(70) Backer and de Boer, *70*, **43**: 420; 24. (71) Baeyer, *25*, **28**: 639; 95. (72) Baker and Pope, *4*, **77**: 696; 00. (73) Baker and Smith, *Researches on the pines of Australia.* Sydney, 1910. (74) Bamberger, *25*, **23**: 291; 90. (75) Bondzynski, *25*, **29**: 476; 96. (76) Bondzynski and Humnicki, *202*, **22**: 396; 97. (77) Barbier, *27*, **9**: 914; 92. (78) Barbier, *34*, **114**: 126; 92. (79) Barbier, *34*, **114**: 674; 92.

(80) Barbier, *27*, **9**: 998; 93. (81) Barbier, *34*, **116**: 993; 93. (82) Barbier, *34*, **116**: 1459; 93. (82.5) Barbier and Bouveault, *34*, **122**: 529; 96. (83) Barbier and Grignard, *34*, **147**: 597; 08. (84) Barbier and Hilt, *34*, **108**: 519; 89. (85) Barbier and Locquin, *14*, **2**: 389; 15. (86) Bargellini, *172 (7th)*, **4A**: 332; 10. (87) Barger, *4*, **97**: 466; 10. (88) Barger and Carr, *4*, **91**: 337; 07. (89) Barger and Ewins, *4*, **97**: 284; 10.

(90) Barrowclift and Tutin, *4*, **95**: 1966; 09. (91) Basquin, *Thesis*, Zürich, 1915. *10*, **4**: 584; 21. (92) Bates and Jackson, *31A*, **13**: 127; 17. (93) Bau, *136*, **21**: 185; 97. (93.5) Bau, *282*, **16**: 397; 99. (94) Bau, *136*, **26**: 69; 02. (95) Bau, *445*, **54**: 481; 04. (95.5) Bauer, *518*, **36**: 304; 89. (96) Baumann, *25*, **15**: 1731; 82. (97) Baumann, *202*, **8**: 299; 84. (98) Béchaump, *34*, **39**: 653; 54. (99) Beckel, *293*, **249**: 329; 11.

(100) Becker, *25*, **14**: 1028; 81. (101) Beckmann, *13*, **250**: 322; 89. (102) Beckmann, *13*, **292**; 1; 96. (103) Beckmann, *52*, **55**: 14; 97. (103.5) Beckmann, *52*, **55**: 31; 97. (104) Beckmann and Eickelberg, *25*, **29**: 418; 96. (105) Beckmann and Pleissner, *13*, **262**; 1; 91. (106) Béhal, *6*, **20**: 411; 00. (107) Behrend, *13*, **353**: 106; 07. (108) Behrend and Lohr, *13*, **362**: 78; 08. (109) Bennet and Gibson, *4*, **123**: 1570; 23.

(110) Berend, *25*, **11**: 1353; 78. (111) Berend and Herms, *52*, **74**: 112; 06 (111.5) Bergmann, Kobel, Schotte, Rennert and Ludewig, *13*, **434**: 79; 23. (112) Bergmann, Schotte and Leschinsky, *25*, **56**: 1052; 23. (113) Bergmann and Wolff, *25*, **56**: 1060; 23. (114) Berkenheim, *25*, **25**: 686; 92. (115) Berlingozzi, *36*, **50 II**: 281; 20. (116) Bernheimer, *36*, **13**: 451; 83. (117) Berthelot, *6*, **40**: 5; 54. (118) Berthelot, *6*, **46**: 66; 56. (119) Berthelot, *49*, **29**: 38; 56. (119.5) Berthelot, *6*, **55**: 269; 59.

(120) Berthelot, *167*, **1862**: 441. (121) Berthelot, *167*, **1862**: 456. (122) Bertolo, *36*, **41 I**: 705; 11. (123) Bertolo, *36*, **53**: 721; 23. (124) Bertolo and Ranfaldi, *36*, **35 II**: 235; 05. (125) Bertossa, *Thesis*, Zürich, 1916. *10*, **4**: 584; 21. (125.05) Bertram and Gildemeister, *52*, **49**: 185; 94. (125.1) Bertram and Helle, *52*, **61**: 293; 00. (125.5) Bertram and Walbaum, *52*, **49**: 15; 94. (126) Bertrand, *27*, **5**: 554; 91. (127) Bertrand, *34*, **139**: 802; 04. (128) Bertrand, *27*, **31**: 1289; 04. (129) Bertrand, *34*, **147**: 201; 08.

(130) Bertrand, *34*, **150**: 180; 10. (131) Bertrand and Bruneau, *34*, **146**: 482; 08. (133) Bertrand and Lanzenberg, *34*, **143**: 291; 06. (135) Bertrand and Weisweiler, *27*, **9**: 38; 11. (136) Betti, *36*, **36 II**: 392; 06. (137) Betti, *36*, **36 II**: 666; 06. (138) Betti, *36*, **37 I**: 62; 07. (139) Betti, *36*, **37 II**: 5; 07.

(140) Betti and Capaccioli, *36*, **50 II**: 276; 20. (141) Betti and Conestabile, *36*, **46 I**: 200; 16. (142) Betti and Mayer, *25*, **41**: 2071; 08. (143) Beyer, *293*, **221**: 283; 83. (144) Biland, *Thesis*, Zürich, 1915. *10*, **4**: 584; 21. (144.5) Binz, in Wallach, *13*, **277**: 154; 93. (145) Binz, *7*, **12**: 723; 93. (145.5) Biot, *151*, **15**: 93; 38. (146) Biot, *151*, **16**: 229; 38. (146.5) Biot, *6*, **28**: 99; 50. (147) Biot, *6*, **36**: 257; 52. (148) Bischoff and Walden, *Handbuch der Stereochemie*, p. 220. Frankfurt, 1894. (149) Blaise, *34*, **132**: 478; 01.

(150) Blaise and Marcilly, *27*, **31**: 317; 04. (151) Blanksma and van Ekenstein, *176*, **5**: 777; 08. (152) Bleyer and Paczuski, *202*, **84**: 1; 13. (153) Bloch, *27*, **31**: 71; 04. (154) Blumann and Zeitschel, *25*, **46**: 1178; 13. (155) Bodart, *57*, **23**: 1; 02. (156) Boedtker, *34*, **145**: 329; 07. (157) Boedtker, *34*, **154**: 437; 12. (158) Boedtker, *27*, **17**: 360; 15. (159) Böhm, in Ritthausen and Weger, *52*, **30**: 32; 84.

(160) Böhme, *293*, **241**: 1; 03. (161) de Boer, *Thesis*, Groningen, 1923. (162) Horowitz, Böttcher and Horowitz, *57*, **32**: 793; 11. (163) Böttcher and *57*, **33**: 567; 12. (164) Bondonneau, *27*, **25**: 2; 76. (165) Borzekowski, *Thesis*, Zürich, 1913. *10*, **4**: 584; 21. (166) Bosshart, *Thesis*, Zürich, 1914. *10*, **4**: 584; 21. (167) Bouchardat, *34*, **19**: 1174; 44. (168) Bouchardat, *6*, **27**: 68, 145; 72. (169) Bouchardat, *34*, **102**: 435; 86.

(170) Bouchardat, *34*, **116**: 1253; 93. (171) Bouchardat, *34*, **117**: 1094; 93. (172) Bouchardat and Boudet, *49*, **23**: 288; 53. (173) Bouchardat and Lafont, *34*, **102**: 318; 86. (173.5) Bouchardat and Lafont, *34*, **102**: 433; 86. (174) Bouchardat and Lafont, *6*, **9**: 507; 86. (175) Bouchardat and Lafont, *34*, **104**: 693; 87. (176) Bouchardat and Lafont, *6*, **16**: 236; 89. (177) Bouchardat and Lafont, *34*, **113**: 551; 91. (178) Bourdier, *49*, **27**: 49; 08. (179) Bourgault, *27*, **25**: 484; 01.

(180) Bourquelot, *172 (7th)*, **8B**: 124; 10. (181) Bourquelot, *49*, **9**: 603; 14. (181.5) Bourquelot, *14*, **7**: 153; 17. (182) Bourquelot and Aubry, *34*, **163**: 60; 16. (183) Bourquelot and Aubry, *34*, **163**: 312; 16. (184) Bourquelot, *34*, **163**: 374; 16. (185) Bourquelot and Aubry, *49*, **14**: 193; 16. (186) Bourquelot and Aubry, *49*, **15**: 246; 17. (187) Bourquelot and Aubry, *34*, **164**: 443; 17. (188) Bourquelot and Aubry, *34*, **164**: 521; 17. (189) Bourquelot and Bridel, *34*, **150**: 114; 10. (189.5) Bourquelot and Bridel, *34*, **151**: 760; 10.

(190) Bourquelot and Bridel, *34*, **155**: 86; 12. (191) Bourquelot and Bridel, *34*, **155**: 437; 12. (192) Bourquelot and Bridel, *34*, **155**: 523; 12. *49*, **6**: 298; 12. (193) Bourquelot and Bridel, *34*, **155**: 854; 12. (194) Bourquelot and Bridel, *49*, **5**: 388; 12. (195) Bourquelot and Bridel, *49*, **6**: 56; 12. (195.5) Bourquelot and Bridel, *49*, **6**: 97; 12. (196) Bourquelot and Bridel, *49*, **6**: 193; 12. (197) Bourquelot and Bridel, *49*, **6**: 442; 12. (197.5) Bourquelot and Bridel, *6*, **29**: 145; 13. (198) Bourquelot and Bridel, *34*, **156**: 827; 13. (199) Bourquelot and Bridel, *34*, **156**: 1104; 13.

(200) Bourquelot and Bridel, *34*, **157**: 72; 13. (201) Bourquelot and Bridel, *49*, **7**: 335; 13. (202) Bourquelot and Bridel, *49*, **7**: 444; 13. (203) Bourquelot and Bridel, *49*, **8**: 108; 13. (204) Bourquelot and Bridel, *49*, **8**: 204; 13. (205) Bourquelot and Bridel, *49*, **9**: 383, 514; 14. (206) Bourquelot, Bridel and Aubry, *34*, **160**: 214; 15. (206.5) Bourquelot, Bridel and Aubry, *34*, **160**: 571; 15. (207) Bourquelot, Bridel and Aubry, *34*, **160**: 674; 15. (208) Bourquelot, Bridel and Aubry, *49*, **11**: 201; 15. (209) Bourquelot, Bridel and Aubry, *49*, **11**: 290; 15.

(210) Bourquelot and Danjou, *34*, **141**: 598; 05. (211) Bourquelot and Fichtenholz, *49*, **2**: 97; 10. (212) Bourquelot and Hérissey, *49*, **4**: 385; 96. (213) Bourquelot and Hérissey, *6*, **4**: 289; 05. (214) Bourquelot and Hérissey, *34*, **144**: 575; 07. (215) Bourquelot and Hérissey, *34*, **146**: 764; 08. (216) Bourquelot and Hérissey, *49*, **8**: 49; 13. (217) Bourquelot, Hérissey and Bridel, *34*, **156**: 1493; 13. (218) Bourquelot, Hérissey and Bridel, *49*, **7**: 285; 13. (219) Bourquelot, Hérissey and Bridel, *49*, **7**: 525; 13.

(220) Bourquelot, Hérissey and Coirre, *49*, **8**: 441; 13. (221) Bourquelot and Ludwig, *49*, **9**: 441; 14. (222) Bourquelot and Ludwig, *34*, **158**: 1377; 14. (223) Bourquelot and Ludwig, *34*, **159**: 213; 14. (224) Bourquelot and Mougne, *49*, **10**: 157; 14. (225) Boutroux, *6*, **21**: 565; 90. (226) Bouveault and Levallois, *34*, **146**: 180; 1908. (227) Bowack and Lapworth, *4*, **85**: 42; 04. (228) von Braun, *25*, **38**: 3108; 05. (229) von Braun and Lemke, *25*, **56**: 1562; 23.

(230) Brauns, *64P*, **10**: 563; 18. (231) Brauns, *1*, **45**: 833; 23. (232) Brauns, *1*, **45**: 2381; 23. (233) Brauns, *1*, **46**: 1484; 24. (234) Bredig and Joyner, *9*, **24**: 285; 18. (234.5) Bredt, *52*, **87**: 1; 13. (235) Bredt, Engels, Lieser and Germann, *52*, **106**: 336; 23. (236) Bredt and Perkin, *182*, **28**: 56; 12. (237) Bredt and Perkin, *4*, **103**: 2182; 13. (238) Bredt and Perkin, *52*, **89**: 209; 14. (239) Bremer, *25*, **8**: 1594; 75.

(240) Bremer, *25*, **13**: 351; 80. (241) Bremy-Schulthess, *Thesis*, Zürich, 1915. *10*, **4**: 584; 21. (242) Bridel, *49*, **4**: 545; 11. (243) Bridel, *49*, **6**: 481; 12. (244) Bridel, *49*, **7**: 241; 13. (245) Bridel, *34*, **156**: 627; 13. *49*, **7**: 289; 13. (246) Bridel, *49*, **8**: 241; 13. (247) Briggs, *4*, **99**: 1019; 11. (248) Brown and Heron, *13*, **199**: 228: 80. (249) Brown and Morris, *4*, **55**: 449; 89.

(250) Brown, Morris and Millar, *4*, **71**: 109; 07. (251) Brühl, *25*, **25**: 1796; 92. (252) Bruhot, *83*, **10**: 84; 14. (253) Bruhot, *14*, **3**: 121; 15. (254) Bruhot, *16*, **3**: 232; 15. (255) Bruhot, *16*, **3**: 417; 15. (256) Bruns, *293*, **241**: 634; 03. (257) Buchner and Weigand, *25*, **46**: 759; 13. (258) Buckney, *201*, **14**: 177; 07. (259) Buckney and Jones, *4*, **91**: 1821; 07.

(260) Buraczewski and Marchlewski, *202*, **43**: 410; 05. (261) Burgess and Lowry, *4*, **123**: 1867; 23. (262) Calliess, *293*, **250**: 156; 12. (263) Cannizaro and Fabris, *25*, **19**: 2260; 86. (264) Carlet, *34*, **53**: 343; 61. (265) Carnelutti and Nasini, *25*, **13**: 2208; 80. (266) Carr, *4*, **101**: 2241; 12. (267) Carr and Pyman, *4*, **105**: 1591; 14. (268) Carr and Reynolds, *4*, **97**: 1328; 10. (269) Carr and Reynolds, *4*, **101**: 946; 12.

(270) Casale, *36*, **47**: 191; 17. (270.5) Cazeneuve, *27*, **37**: 454; 82. **38**: 8; 82. (271) Cazeneuve, *34*, **94**: 1530; 82. (271.5) Cazeneuve, *27*, **42**: 69; 84. (272) Cazeneuve, *34*, **99**: 609; 84. (272.5) Cazeneuve, *27*, **44**: 115; 85. (273) Cazeneuve, *34*, **103**: 275; 86. (274) Cazeneuve, *34*, **104**: 1522; 87. (275) Cazeneuve, *27*, **47**: 920; 87. (276) Cazeneuve, *27*, **49**: 92; 88. (277) Cazeneuve, *34*, **108**: 302; 89. (278) Cazeneuve, *34*, **108**: 857; 89. (279) Cazeneuve, *34*, **109**: 229; 89.

(280) Cazeneuve, *34*, **109**: 439; 89. (281) Challenger and Kipping, *4*, **97**: 142; 10. (282) Challenger and Kipping, *4*, **97**: 755; 10. (283) Champion and Pellet, *34*, **82**: 819; 76. (284) Chapman, *4*, **79**: 134; 01. (285) Chautard, *34*, **37**: 166; 53. (286) Chautard, *49*, **44**: 13; 63. (287) Chavanne, *34*, **134**: 661; 02. (288) Chou and Perkin, *4*, **99**: 526; 11. (289) Christensen, *52*, **68**: 425; 03.

(290) Christensen, *52*, **69**: 193; 04. (291) Christensen, *52*, **71**: 1; 05. (292) Christie, James and Kenner, *4*, **123**: 1948; 23. (292) Christie and Kenner, *4*, **123**: 779; 23. (293.5) Christopher and Hilditch, *4*, **101**: 202; 12. (294) Chugaev, *25*, **31**: 360; 98. (295) Chugaev, *25*, **31**: 1775; 98. (296) Chugaev, *25*, **32**: 3332; 99. (297) Chugaev, *25*, **34**: 2276; 01. (298) Chugaev, *53*, **34**: 606; 02. (299) Chugaev, *25*, **35**: 2473; 02.

(300) Chugaev, *53*, **35**: 1116; 03. (301) Chugaev, *53*, **36**: 988; 04. (302) Chugaev, *25*, **42**: 2244; 09. (303) Chugaev, *172 (7th)*, **10**: 142; 10. (304) Chugaev, *6*, **22**: 137; 11. (305) Chugaev, *25*, **44**: 2023; 11. (306) Chugaev, *7*, **76**: 469; 11. (307) Chugaev, *27*, **11**: 718; 12. (308) Chugaev, *27*, **13**: 793; 13. (309) Chugaev, *83*, **10**: 70; 14.

(310) Chugaev and Esche, *53*, **39**: 1324; 07. (311) Chugaev and Fomin, *34*, **151**: 1058; 10. (312) Chugaev and Fomin, *13*, **375**: 288; 10. (313) Chugaev and Fomin, *25*, **45**: 1293; 12. (314) Chugaev and Glebho, *25*, **46**: 2752; 13. (315) Chugaev and Glinnin, *25*, **45**: 2579; 12. (316) Chugaev and Kirpichev, *27*, **13**: 796; 13. (317) Chugaev and Ogorodnikov, *7*, **74**: 503; 10. (317.5) Chugaev and Ogordnikov, *6*, **22**: 137; 11. (318) Chugaev and Ogorodnikov, *7*, **79**: 471; 12. (319) Chugaev and Ogorodnikov, *7*, **85**: 481; 13.

(320) Chugaev and Pastanogov, *7*, **85**: 553; 13. (321) Chugaev and Pigulevskii, *34*, **153**: 388; 11. (322) Chugaev and Sokolov, *25*, **40**: 3461; 07. (323) Chugaev and Sokolov, *25*, **42**: 55; 09. (324) Chugaev and Teearu, *25*, **46**: 1769; 13. (325) Claesson, *52*, **20**: 1; 79. (326) Clarke and Lapworth, *4*, **89**: 1869; 16. (327) Clarke and Lapworth, *4*, **91**: 694; 07. (328) Clarke and Lapworth, *4*, **97**: 11; 10. (329) Claus and Weller, *25*, **14**: 1921; 81.

(330) Clough, *4*, **105**: 49; 14. (331) Clough, *4*, **107**: 96; 15. (332) Clough, *4*, **107**: 1509; 15. (333) Clough, *4*, **113**: 526; 18. (334) Clowes and Tollens, *13*, **310**: 164: 99. (334.5) Cockburn, *4*, **75**: 501; 99. (335) Cohen, *64P*, **9**: 471; 06. (336) Cohen, *4*, **99**: 1058; 11. (336.5) Cohen and Armes, *4*, **87**: 1190; 05. (337) Cohen and Armes, *4*, **89**: 1479; 06. (338) Cohen and Briggs, *4*, **83**: 1213; 03. (339) Cohen and Dudley, *4*, **97**: 1732; 10.

(340) Cohen and Marshall, *4*, **97**: 328; 10. (341) Cohen, Marshall and Woodman, *4*, **107**: 887; 15. (341.5) Cohen and Pennington, *4*, **113**: 57; 18. (342) Cohen and Raper, *4*, **85**: 1262; 04. (343) Cohen and Whitely, *4*, **79**: 1305; 01. (344) Cohen, Woodroffe and Anderson, *4*, **109**: 222; 16. (345) Cohen and Zortmann, *4*, **89**: 47; 06. (346) Cohn, *57*, **21**: 200; 00. (347) Colley, *34*, **70**: 401; 70. (348) Colson, *34*, **114**: 175; 92. (349) Colson, *34*, **115**: 729; 92.

(350) Combes, *34*, **110**: 46; 90. (351) Commanducci, *71*, **16**: 51; 10. (352) Comstock and Königs, *25*, **20**: 2510; 87. (353) Conrad and Guthzeit, *25*, **18**: 2905; 85. (354) Cook, *25*, **30**: 294; 97. (355) Corriez, *345*, **19**: 468; 12. (356) Corriez, *345*, **19**: 527; 12. (357) Cramer, *145*, **24**: 67; 88. (358) Creydt, *Diss.*, Erlangen, 1888. (359) Crossely, *25*, **25**: 2564; 92.

(360) Czerny, *25*, **33**: 2287; 00. (361) Dätwiller, *Thesis*, Zürich, 1922. *10*, **5**: 727; 25. (362) Daish, *4*, **105**: 2053; 14. (363) Dakin, *4*, **107**: 434; 15. (364) Dakin, *141*, **59**: 7; 24. (365) Dale, *1*, **37**: 2745; 15. (366) Dale, *1*, **46**: 1046; 24. (367) Darmois, *Thesis*, Paris, 1910. *10*, **1**: 589; 12. (368) Darmois, *83*, **10**: 80; 14. (369) Darmois, *51*, **4**: 49; 23.

(370) Darmois, *34*, **176**: 1140; 23. (371) Darmois, *34*, **177**: 49; 23. (372) Darzens, *34*, **152**: 1601; 11. (373) Darzens and Séjourné, *34*, **154**: 1615; 12. (374) Deckers and Einhorn, *25*, **24**: 7; 91. (374.5) Deichmüller, Szymanski and Tollens, *13*, **228**: 92; 85. (375) Delépine, *27*, **29**: 1190; 03. (376) Delépine, *34*, **159**: 239; 14. (377) Delépine, *27*, **21**: 157; 17. (378) Demole, *25*, **12**: 1936; 79. (379) Denham and Woodhouse, *4*, **105**: 2357; 14.

380) Deussen, *13*, **369**: 41; 09. (381) Deussen, *13*, **388**: 136; 12. (382) Deussen and Hahn, *Z. Reich. Geschmackstoff.*, **1**: 25; 09. (383) Deussen and Lewinsohn, *13*, **356**: 1; 07. (384) Deussen and Lewinsohn, *13*, **359**: 245; 08. (385) Dewar and Jones, *5*, **80**: 229; 08. (386) Dieckmann, *13*, **317**: 27; 01. (387) Diels and Linn, *25*, **41**: 260; 08. (388) Ditmar, *57*, **23**: 865; 02. (389) Dodge, *11*, **11**: 456; 89.

(390) Dodge, *11*, **12**: 553; 90. (391) Doebner, *25*, **27**: 344; 94. (392) Donath, *52*, **33**: 559; 86. (392.5) Dorée and Gardner, *4*, **93**: 1328; 08. (393) Dorée, *4*, **95**: 638; 09. (394) Dott, *347*, **14**: 581; 84. (395) Dragendorff and Spohn, *Pharm. Z. Russe*, **23**: 313, 329, 345, 361, 377; 84. (396) Draper, *12*, **11**: 42; 76. (397) Dubrunfaut, *34*, **42**: 901; 56. (398) Duden and MacIntyre, *13*, **313**: 59; 00. (399) Dunstan and Andrews, *4*, **87**: 1620; 05.

(400) Dunstan and Carr, *4*, **65**: 176; 94. (400.5) Dunstan and Carr, *4*, **71**: 350; 97. (401) Dunstan and Harrison, *4*, **63**: 443; 93. (402) Dunstan and Ince, *4*, **59**: 271; 91. (403) Dunstan and Passmore, *4*, **61**: 395; 92. (404) Dunstan and Thole, *4*, **97**: 1249; 10. (405) Easterfield and Bee, *4*, **97**: 1028; 10. (406) Ebert, *Z. oesterr. Apoth.-Ver.*, **46**: 545; 08. (407) Eckart, *293*, **229**: 355; 91. (408) Edminson and Hilditch, *4*, **97**: 223; 10. (409) Ehrlich, *445*, **53**: 809; 03. (409.5) Ehrlich, *25*, **37**: 1809; 04.

(410) Ehrlich, *25*, **40**: 2538; 07. (411) Ehrlich and Jacobsen, *25*, **44**: 888; 11. (412) Ehrlich and Wendel, *205*, **8**: 399; 08. (413) Ehrlich and Wendel, *205*, **8**: 438; 08. (414) Ehrlich and Wendel, *445*, **58**: 198; 08. (415) Eijkman, *70*, **5**: 290; 86. (416) Eijkman, *25*, **24**: 1278; 91. (416.5) Einhorn, *25*, **22**: 1495; 89. (417) Einhorn and Marquardt, *25*, **23**: 468; 90. (417.5) Einhorn and Marquardt, *25*, **23**: 979; 90. (418) Einhorn and Tahara, *25*, **26**: 324; 93. (419) van Ekenstein, *70*, **15**: 221; 96.

(420) van Ekenstein and Blanksma, *70*, **24**: 33; 05. (421) van Ekenstein and Blanksma, *70*, **25**: 153; 06. (422) van Ekenstein and Blanksma, *70*, **25**: 162; 06. (423) van Ekenstein and Blanksma, *70*, **27**: 1; 08. (424) van Ekenstein and Blanksma, *176*, **4**: 743; 08. (425) van Ekenstein and Blanksma, *176*, **6**: 373; 09. (426) van Ekenstein and Lobry de Bruyn, *70*, **19**: 178; 00. (426.5) Emde, *293*, **244**: 241; 06. (427) Emmerling, *25*, **41**: 1373; 08. (428) Engels, *25*, **33**: 1087; 00. (429) Enklaar, *176*, **7**: 1; 10.

(430) Erlenmeyer, *25*, **39**: 285; 06. (430.5) Erlenmeyer, *25*, **39**: 788; 06. (431) Erlenmeyer, *25*, **39**: 791; 06. (432) Erlenmeyer and Arnold, *13*, **337**: 307; 04. (433) Erlenmeyer and Barkow, *25*, **39**: 1570; 06. (434) Erlenmeyer and Hell, *13*, **160**: 257; 71. (434.5) Ertschikowsky, *53*, **28**: 132; 95. (435) Étard, *34*, **97**: 1218; 83. (436) Evans, *4*, **97**: 2237; 10. (437) Everatt, *4*, **93**: 1225; 08. (438) Everatt and Jones, *4*, **93**: 1789; 08. (439) Ewins, *4*, **97**: 2406; 10.

(440) Fajans, *7*, **73**: 25; 10. (441) Faltis, *57*, **33**: 873; 12. (441.5) Farnsteiner, *25*, **23**: 3570; 90. (442) Faucon, *34*, **154**: 652; 12. (443) Fauconnier, *27*, **41**: 119; 84. (444) Faust, *277*, **43**: 84; 00. (445) Fayollat, *34*, **117**: 630; 93. (446) Feinberg, *202*, **84**: 363; 13. (447) Feist, *293*, **246**: 206; 08. (448) Feist, *293*, **247**: 226; 09. (449) Feist, *293*, **250**: 668; 12. (449.5) Feist, *13*, **436**: 125; 24.

(450) Feist and Arnstein, *25*, **28**: 3167; 95. (451) Ferns and Lapworth, *4*, **101**: 273; 12. (452) Fileti, *52*, **46**: 560; 92. (453) Fileti, *36*, **22 II**: 395; 92. (454) Finkelbeiner, *25*, **27**: 889; 94. (455) Fischer, *25*, **23**: 370; 90. (456) Fischer, *25*, **23**: 2611; 90. (456.5) Fischer, *25*, **23**: 2625; 90. (457) Fischer, *25*, **24**: 539; 91. (458) Fischer, *25*, **24**: 1836; 91. (459) Fischer, *25*, **24**: 2683; 91.

(460) Fischer, *25*, **24**: 3622; 91. (461) Fischer, *13*, **270**: 64; 92. (462) Fischer, *25*, **26**: 633; 93. (463) Fischer, *25*, **26**: 1973; 93. (464) Fischer, *25*, **27**: 673; 94. (465) Fischer, *25*, **27**: 1524; 94. (465.5) Fischer, *25*, **28**: 1145; 95. (466) Fischer, *13*, **288**: 139; 95. (467) Fischer, *25*, **32**: 3638; 99. (467.5) Fischer, *25*, **33**: 2370; 00. (468) Fischer, *76*, **1900**: 1062. (469) Fischer, *202*, **33**: 150; 01.

(470) Fischer, *25*, **38**: 2914; 05. (471) Fischer, *25*, **39**: 453; 06. (472) Fischer, *25*, **39**: 2320; 06. (473) Fischer, *25*, **39**: 2893; 06. (474) Fischer, *25*, **40**: 489; 07. (475) Fischer, *25*, **40**: 1754; 07. (476) Fischer, *25*, **40**: 3704; 07. (477) Fischer, *25*, **40**: 5000; 07. (478) Fischer, *13*, **354**: 1; 07. (479) Fischer, *25*, **41**: 850; 08.

(480) Fischer, *25*, **41**: 2860; 08. (481) Fischer, *76*, **1908**: 542. (482) Fischer, *202*, **70**: 256; 11. (483) Fischer, *25*, **47**: 196; 14. (484) Fischer, *25*, **47**: 456; 14. (485) Fischer, *25*, **47**: 1377; 14. (486) Fischer, *25*, **47**: 3193; 14. (486.5) Fischer, *25*, **48**: 93; 15. (487) Fischer, *25*, **48**: 266; 15. (488) Fischer and Armstrong, *25*, **34**: 2885; 01. (489) Fischer and Armstrong, *25*, **35**: 833; 02.

(490) Fischer and Armstrong, *25*, **35**: 3153; 02. (491) Fischer and Beensch, *25*, **29**: 2927; 96. (492) Fischer and Begell, *25*, **36**: 2592; 03. (493) Fischer and Breiger, *25*, **48**: 1517; 15. (494) Fischer and Bromberg, *25*, **29**: 581; 96 (495) Fischer and Carl, *25*, **39**: 3996; 06. (496) Fischer and Cone, *13*, **363**: 107; 08. (497) Fischer and Curme, *25*, **47**: 2047; 14. (498) Fischer and Delbruck, *25*, **42**: 1476; 09. (499) Fischer and Fay, *25*, **28**: 1975; 95.

(500) Fischer and Flatau, *76*, **1909**: 876. (501) Fischer and von Fodor, *25*, **47**: 1058; 14. (502) Fischer and Fodor, *25*, **47**: 2057; 14. (503) Fischer and Freudenberg, *25*, **45**: 915; 12. (504) Fischer and Freudenberg, *25*, **46**: 1116; 13. (505) Fischer and Gerngross, *25*, **42**: 1485; 09. (506) Fischer and Grävenitz, *13*, **406**: 1; 14. (507) Fischer and Groh, *13*, **383**: 363; 11. (508) Fischer and Hagenbach, *25*, **34**: 3764; 01. (508.5) Fischer and Helferich, *13*, **383**: 68; 11. (509) Fischer and Helferich, *25*, **47**: 210; 14.

(510) Fischer and Herborn, *25*, **29**: 1961; 96. (511) Fischer and Hertz, *25*, **25**: 1247; 92. (512) Fischer and Hirschberger, *25*, **22**: 365; 89. (513) Fischer and Hirschberger, *25*, **22**: 1155; 89. (514) Fischer and Hirschberger, *25*, **22**: 3218; 88. (515) Fischer, Holzapfel and Gewinner, *25*, **45**: 247; 12. (516) Fischer and Jacobs, *25*, **39**: 2942; 06. (517) Fischer and Jacobs, *25*, **40**: 1057; 07. (518) Fischer and Kögl, *13*, **436**: 219; 24. (519) Fischer and Koenings, *25*, **37**: 4585; 04.

(520) Fischer and Koenings, *25*, **40**: 2048; 07. (521) Fischer, Kropp and Stahlschmidt, *13*, **365**: 181; 09. (522) Fischer and Leuchs, *25*, **35**: 3787; 02. (523) Fischer and Lipschitz, *25*, **48**: 360; 15. (524) Fischer and Meckel, *25*, **49**: 1355; 16. (525) Fischer and Meckel, *25*, **49**: 2813; 16. (526) Fischer and Moreschi, *25*, **45**: 2447; 12. (527) Fischer and Mouneyrat, *25*, **33**: 2383; 00. (528) Fischer and Oetker, *25*, **46**: 4029; 13. (529) Fischer and Passmore, *25*, **23**: 2226; 90. (529.5) Fischer and Perkin, *4*, **93**: 1871; 08.

(530) Fischer and Piloty, *25*, **23**: 3102; 90. (531) Fischer and Piloty, *25*, **23**: 3827; 90. (532) Fischer and Piloty, *25*, **24**: 521; 91. (533) Fischer and Piloty, *25*, **24**: 4214; 91. (534) Fischer and Rapaport, *25*, **46**: 2389; 13. (535) Fischer and Raske, *13*, **340**: 180; 05. (536) Fischer and Raske, *76*, **1906**: 371. (537) Fischer and Raske, *25*, **39**: 3981; 06. (538) Fischer and Raske, *25*, **41**: 893; 08. (539) Fischer and Raske, *25*, **42**: 1465; 09.

(540) Fischer and Reif, *13*, **363**: 118; 08. (541) Fischer, Rhode and Brauns, *13*, **402**: 364; 13. (542) Fischer and Ruff, *25*, **33**: 2142; 00. (543) Fischer and Rund, *25*, **49**: 88; 16. (544) Fischer and Scheibler, *13*, **363**: 136; 08. (545) Fischer and Scheibler, *13*, **383**: 337; 11. (546) Fischer and Schoeller, *13*, **357**: 1; 07. (547) Fischer and Schulze, *25*, **40**: 943; 07. (548) Fischer and Slimmer, *76*, **1902**: 597. (549) Fischer and Steingroever, *13*, **365**: 167; 09.

(550) Fischer and Strauss, *25*, **45**: 2467; 12. (551) Fischer and Strauss, *25*, **45**: 3773; 12. (552) Fischer and Suzuki, *25*, **37**: 4575; 04. (553) Fischer and Tafel, *25*, **20**: 2566; 87. (554) Fischer and Warburg, *13*, **340**: 152; 05. (555) Fischer and Warburg, *13*, **340**: 168; 05. (556) Fischer and Warburg, *25*, **38**: 3997; 05. (557) Fischer and Weichhold, *25*, **41**: 1286; 08. (558) Fischer and Zach, *25*, **44**: 132; 11. (559) Fischer and Zach, *25*, **45**: 456; 12.

(560) Fischer and Zach, *25*, **45**: 2068; 12. (561) Fischer and Zemplén, *515*, **17**: 33; 11. (561.2) Fischer and Zemplén, *25*, **42**: 2989; 09. (561.5) Fischlin, *Thesis*, Zürich, 1920. *10*, **5**: 727; 25. (563) Flächer, *202*, **58**: 189; 08. (564) Flavickij, *25*, **11**: 1846; 78. (565) Flavickij, *25*, **12**: 2354; 79. (566) Flavickij, *25*, **20**: 1956; 87. (567) Flavickij, *52*, **45**: 115; 92. (568) Flood, *Thesis*, Zürich, 1914. *10*, **4**: 584; 21. (569) Flückiger, *495*, **5**: 1; 56.

(570) Flückiger, *293*, **222**: 361; 84. (571) Foerster, *25*, **23**: 2981; 90. (572) Forschbach, *494*, **8**: 313; 06. (573) Forster, *4*, **71**: 1030; 97. (574) Forster, *4*, **73**: 386; 98. (575) Forster, *4*, **75**: 934; 99. (576) Forster, *4*, **75**: 1149; 99. (577) Forster, *4*, **77**: 251; 00. (578) Forster, *4*, **79**: 644; 01. (579) Forster, *4*, **79**: 653; 01.

(580) Forster, *4*, **79**: 987; 01. (581) Forster, *4*, **79**: 1003; 01. (582) Forster, *4*, **81**: 264; 02. (583) Forster, *4*, **81**: 865; 02. (584) Forster, *4*, **83**: 98; 03. (585) Forster, *4*, **83**: 514; 03. (586) Forster, *4*, **85**: 892; 04. (587) Forster, *4*, **87**: 232; 05. (588) Forster, *4*, **89**: 222; 06. (589) Forster, *4*, **103**: 662; 13.

(590) Forster and Attwell, *4*, **85**: 1188; 04. (591) Forster and Fierzz, *4*, **87**: 110; 05. (592) Foster and Fierzz, *4*, **87**: 722; 05. (593) Forster and Fierzz, *4*, **87**: 826; 05. (594) Forster and Fierzz, *4*, **91**: 867; 07. (595) Forster and Garland, *4*, **95**: 2051; 09. (596) Forster and van Gelderen, *4*, **99**: 2059; 11. (596.5) Forster and van Gelderen, *182*, **27**: 195; 11. (597) Forster and Grossmann, *4*, **89**: 402; 06. (598) Forster and Hart-Smith, *4*, **77**: 1152; 00. (599) Forster and Holmes, *4*, **93**: 242; 08.

(600) Forster and Jackson, *4*, **91**: 1877; 07. (601) Forster and Jenkinson, *4*, **83**: 537; 03. (602) Forster and Judd, *4*, **87**: 368; 05. (603) Forster and Judd, *4*, **97**: 254; 10. (604) Forster and Kunz, *4*, **105**: 1718; 14. (605) Forster and Micklethwaite, *4*, **81**: 160; 02. (606) Forster and Micklethwaite, *4*, **81**: 406; 02. (607) Forster and Müller, *4*, **95**: 191; 09. (608) Forster and Spencer, *4*, **101**: 1340; 12. (609) Forster and Spinner, *4*, **115**: 889; 19.

(610) Forster and Stötter, *4*, **99**: 1337; 11. (611) Forster and Thornley, *4*, **95**: 942; 09. (612) Forster, Trotter and Weintraube, *4*, **99**: 1982; 11. (613) Forster and Withers, *4*, **101**: 1327; 12. (614) Forster and Zimmerli, *4*, **97**: 2156; 10. (615) Forster and Zimmerli, *4*, **99**: 478; 11. (616) Foulkes, *49*, **14**: 364; 16. (617) Fourneau and Sandulesco, *27*, **33**: 459; 23. (618) Fox and Gauge, *4*, **99**: 1075; 11. (619) Fraenkel, *Thesis*, Zürich, 1913. *10*, **4**: 584; 21.

(620) Fränkel, Herschmann and Tritt, *25*, **56**: 433; 23. (621) Fragner, *25*, **21**: 3284; 88. (622) Francesconi, *22*, **12 II**: 204; 03. (622.5) Francesconi, *22*, **12 II**: 267, 304; 03. (623) Francesconi and Cusmano, *36*, **39 II**: 105; 09. (624) Francesconi and Cusmano, *36*, **39 II**: 115; 09. (625) Francesconi and Ferrulli, *36*, **33 I**: 188; 03. (626) Francesconi and Maggi, *36*, **33 II**: 65; 03. (627) Francesconi and Vendetti, *36*, **32 I**: 281; 02. (628) Franchimont and Backer, *64V*, **23**: 647; 15. (629) Franchimont and Backer, *64P*, **17**: 653; 15.

(630) François and Luce, *49*, **25**: 500; 22. (631) Franke and Dworzak, *57*, **43**: 661; 23. (632) Frankland and Appleyard. *4*, **63**: 296: 93. (633) Frankland and Aston, *4*, **75**: 493; 99. (634) Frankland and Aston, *4*, **79**:

511; 01. (635) Frankland and Barrow, *4*, **95**: 2017, 2026; 09. (636) Frankland and Barrow, *4*, **105**: 990; 14. (637) Frankland, Carter and Adams, *4*, **101**: 2470; 12. (638) Frankland and Done, *4*, **87**: 618; 05. (639) Frankland and Done, *4*, **89**: 1859; 06.

(640) Frankland and Frew, *4*, **59**: 96; 91. (641) Frankland and Garner, *4*, **115**: 636; 191. (642) Frankland and Gebhard, *4*, **87**: 864; 05. (643) Frankland and Harger, *4*, **85**: 1571; 04. (644) Frankland, Heathcote and Green, *4*, **83**: 168; 03. (645) Frankland, Heathcote and Harble, *4*, **83**: 154; 03. (646) Frankland and Henderson, *182*, **11**: 54; 95. (647) Frankland and McCrae, *4*, **73**: 307; 98. (648) Frankland and MacGregor, *4*, **61**: 737; 92. (649) Frankland and MacGregor, *4*, **63**: 511, 1410; 93.

(650) Frankland and MacGregor, *4*, **69**: 104; 96. (651) Frankland and Ormerod, *4*, **83**: 1342; 03. (652) Frankland and O'Sullivan, *4*, **99**: 2325; 11. (653) Frankland and O'Sullivan, *4*, **101**: 287; 12. (654) Frankland and Patterson, *4*, **73**: 181; 98. (655) Frankland and Price, *4*, **71**: 253; 97. (656) Frankland and Slater, *4*, **83**: 1349; 03. (657) Frankland and Turnbull, *4*, **73**: 203; 98. (658) Frankland and Turnbull, *4*, **105**: 456; 14. (659) Frankland and Twiss, *4*, **85**: 1666; 04.

(660) Frankland and Twiss, *4*, **89**: 1852; 06. (661) Frankland and Twiss, *4*, **97**: 154; 10. (662) Frankland and Wharton, *4*, **69**: 1309, 1583; 96. (663) Frankland and Wharton, *4*, **75**: 337; 99. (664) Frankland, Wharton and Aston, *4*, **79**: 266; 10. (665) Frese, *25*, **33**: 3483; 00. (666) Freudenberg, *25*, **47**: 2027; 14. (667) Freudenberg, Brauns and Siegel, *25*, **56**: 193; 23. (668) Freudenberg and Doser, *25*, **56**: 1243; 23. (669) Freudenberg and Hixon, *25*, **56**: 2119; 23.

(670) Freudenberg and Purrmann, *25*, **56**: 1185; 23. (671) Freund and Fleischer, *25*, **45**: 1171; 12. (672) Freund and Horkheimer, *25*, **39**: 814; 06. (673) Freund and Josephy, *13*, **277**: 1; 93. (674) Freund and Rosenberg, *25*, **23**: 404; 90. (675) Freund and Speyer, *25*, **44**: 2339; 11. (676) Freund and Will, *25*, **19**: 2797; 86. (677) Freundler, *27*: **7**: 804; 92. (678) Freundler, *34*, **115**: 509; 92. (679) Freundler, *27*, **9**: 680; 93.

(680) Freundler, *34*, **117**: 556; 93. (681) Freundler, *6*, **3**: 433; 94. (682) Freundler, *27*, **11**: 366, 470; 94. (683) Freundler, *6*, **4**: 235; 95. (684) Freundler, *27*, **13**: 1055; 95. (685) Freylon, *6*, **15**: 278; 08. (686) Friedel, *34*, **108**: 978; 89. (687) Friedel, *34*, **113**: 825; 91. (688) Friedmann, *494*, **3**: 1; 03. (689) Friedmann, *494*, **8**: 95; 06.

(690) von Friedrichs, *293*, **245**: 427; 07. (691) von Friedrichs, *293*, **257**: 72; 19. (692) Fröhlich, *25*, **44**: 1057; 11. (693) Fröhlich and Wedekind, *25*, **40**: 1009; 07. (694) Fröhlich and Wedekind, *25*, **40**: 1646; 07. (695) Fudakowsky, *25*, **11**: 1069; 78. (696) Furness and Perkin, *4*, **105**: 2024; 14. (697) Gadamer, *293*, **234**: 543; 96. (698) Gadamer, *293*, **239**: 283; 01. (699) Gadamer, *293*, **239**: 663; 01.

(700) Gadamer, *293*, **240**: 18; 02. (701) Gadamer, *293*, **246**: 566; 08. (702) Gadamer, *293*, **249**: 641; 11. (703) Gadamer and Amenomiya, *293*, **242**: 1; 04. (704) Gadamer and Bruns, *293*, **239**: 39; 01. (705) Gadamer and Kuntze, *293*, **249**: 598; 11. (706) Gamgee and Hill, *5*, **71**: 376; 03. (707) Gamgee and Jones, *5*, **71**: 385; 03. (708) Gandurin, *25*, **41**: 4359; 08. (709) Gardiner, Perkin and Watson, *4*, **97**: 1756; 10.

(710) Gardner and Cockburn, *4*, **73**: 275; 98. (711) Gaskell, *289*, **36**: 142; 07. (712) Geake and Nierenstein, *25*, **47**: 891; 14. (713) Gennarri, *7*, **19**: 130; 96. (714) Genvresse, *34*, **137**: 494; 03. (715) Gernez, *34*, **114**: 480; 92. (715.5) Gernez, *34*, **121**: 1150; 95. (716) Ghosh, *68*, **36**: 216; 16. (717) Gibson, *182*, **30**: 32; 14. (718) Gibson and Simonsen, *4*, **107**: 798; 15. (719) Gibson and Simonsen, *4*, **107**: 1148; 15.

(720) Giesma, *25*, **33**: 2996; 00. (721) Girard, *34*, **110**: 84; 90. (722) Glattfield, *11*, **50**: 135; 13. (723) Glover, *4*, **93**: 1285; 08. (724) Glover and Lowry, *4*, **101**: 1902; 12. (725) Gnesotto and Crestani, *59*, **8**: 365; 04. (726) Godchot, *34*, **158**: 1807; 14. (727) Goebel and Noyes, *1*, **45**: 3064; 23. (727.5) Goldschmidt and Fischer, *25*, **30**: 2069; 97. (728) Goldschmidt and Freund, *7*, **14**: 394; 94. (729) Goldschmiedt, *57*, **13**: 691; 92.

(730) Goldschmiedt, *9*, **12**: 416; 06. (731) Goldschmiedt and Zerner, *57*, **31**: 439; 10. (732) Goldschmiedt and Zerner, *57*, **33**: 1379; 12. (733) Goldsworthy and Perkin, *4*, **105**: 2639; 14. (734) Golse, *Thesis*, Bordeaux, 1911. *10*, **2**: 336; 13. (735) Golubev, *53*, **36**: 1096; 04. (736) Golubev, *53*, **44**: 1061; 12. (737) Gordin, *1*, **30**: 265; 08. (738) Gordin, *1*, **33**: 1626; 11. (739) Goris, Mascré and Vischniac, *Sci. Ind. Bull. Roure-Bertrand Fils*, **No. 6**; 1912.

(740) Goris and Vischniac, *345*, **19**: 488; 12. (741) Gorter, *13*, **358**: 327; 08. (742) Gorter, *70*, **30**: 151; 11. (743) Gorter, *70*, **31**: 264; 12. (744) Gorter, *70*, **31**: 281; 12. (745) Graham, *4*, **101**: 746; 12. (746) Granger, *25*, **30**: 1060; 97. (747) Griffin and Nelson, *1*, **37**: 1552; 15. (748) Grimal, *34*, **135**: 1057; 02. (748.5) Grimaux, *34*, **92**: 1228; 81. (749) Grimaux and Arnaud, *34*, **112**: 1364; 91.

(750) Grossmann, *25*, **38**: 1711; 05. (751) Grossmann, *445*, **56**: 1024; 06. (752) Grossmann, *83*, **10**: 60; 14. (752.5) Grossmann and Landau, *7*, **75**: 129; 10. (753) Grossmann and Pötter, *25*, **37**: 84; 04. (754) Grossmann and Pötter, *25*, **38**: 3874; 05. (755) Grossmann and Pötter, *7*, **56**: 577; 06. (756) Grossmann and Wieneke, *7*, **54**: 385; 06. (757) Grün, *25*, **39**: 4400; 06. (758) Grün, *57*, **37**: 409; 16. (758.5) Guareschi, *Ann. chim. farm.* **87**: 113; 87. (759) Gubbe, *25*, **18**: 2207; 85.

(760) Gucci and Grassi-Crestaldi, *36*, **22 I**: 1; 92. (761) Günther and Tollens, *13*. **271**: 86; 92. (762) Guerbet, *27*, **13**: 769; 95. (763) Guerbet, *49*, **1**: 5; 10. (764) Gulevich, *202*, **87**: 1; 13. (765) Gumprich, *63*, **24**: 434; 23. (766) Gurevitsch, *Thesis*, Zürich, 1914. *10*, **4**: 484; 21. (767) Gutt, *25*, **40**: 2061; 07. (767.5) Guye, *6*, **25**: 145; 92. (768) Guye and Amaral, *34*, **120**: 1345; 95. (769) Guye and Amaral, *149*, **33**: 409; 95.

(770) Guye and Aston, *34*, **130**: 585; 00. (771) Guye and Chavanne, *34*, **116**: 1454; 93. (772) Guye and Chavanne, *34*, **120**: 452; 95. (773) Guye and Goudet, *34*, **121**: 827; 95. (774) Guye and Guerchgorine, *34*, **124**: 230; 97. (775) Guye and Jordan, *34*, **120**: 632, 1274; 95. (776) van der Haar, *293*, **250**: 424; 12. (777) Haiser and Wenzel, *57*, **29**: 157; 08. (778) Hall, *4*, **123**: 32; 23. (779) Haller, *Diss.*, Nancy, 1879.

(780) Haller, *34*, **104**: 66; 87. (781) Haller, *34*, **105**: 227; 87. (782) Haller, *34*, **108**: 410; 89. (783) Haller, *34*, **109**: 29; 89. (784) Haller, **110**: 149; 90. (785) Haller, *34*, **112**: 143; 91. (786) Haller, *34*, **113**: 55; 91. (787) Haller, *6*, **27**: 392; 92. (788) Haller, *34*, **114**: 1516; 92. (789) Haller, *34*, **115**: 19; 92.

(790) Haller, *34*, **115**: 97, 143; 92. (791) Haller, *27*, **15**: 984; 96. (792) Haller, *34*, **130**: 688; 00. (793) Haller, *34*, **136**: 788; 03. (794) Haller, *34*, **136**: 1222; 03. (795) Haller, *34*, **140**: 127; 05. (796) Haller, *34*, **140**: 1626; 05, (797) Haller, *34*, **141**: 13; 05. (798) Haller, *34*, **144**: 462; 07. (799) Haller, *34*, **154**: 742; 12.

(800) Haller, *34*, **156**: 1199; 13. (801) Haller, *34*, **157**: 965; 13. (802) Haller and Bauer, *34*, **142**: 677; 06. (803) Haller and Bauer, *34*, **142**: 971; 06. (804) Haller and Bauer, *34*, **148**: 1490; 09. (805) Haller and Bauer, *34*, **148**: 1643; 09. (806) Haller and Bauer, *34*, **156**: 1503; 13. (807) Haller and Blanc, *34*, **141**: 697; 05. (808) Haller and Cornubert, *34*, **158**: 1616; 14. (809) Haller and Cornubert, *34*, **158**: 1739; 14.

(810) Haller and Couréménos, *34*, **140**: 1430; 05. (811) Haller and Desfontaines, *34*, **140**: 1205; 05. (812) Haller and Lassieur, *34*, **151**: 697; 10. (813) Haller and Louvrier, *34*, **158**: 754; 14. (814) Haller and March, *34*, **138**: 1665; 04. (815) Haller and March, *27*, **33**: 969; 05. (816) Haller and March, *34*, **140**: 474; 05. (817) Haller and March, *34*, **140**: 624; 05. (818) Haller and Minguin, *34*, **118**: 690; 94. (819) Haller and Minguin, *27*, **15**: 988; 96.

(820) Haller and Minguin, *34*, **133**: 79; 01. (821) Haller and Minguin, *34*, **136**: 49; 03. (822) Haller and Minguin, *34*, **136**: 1525; 03. (823) Haller and Minguin, *34*, **142**: 1309; 06. (824) Haller and Muller, *34*, **129**: 1005; 99. (825) Hann and Lapworth, *4*, **85**: 46; 04. (825.5) Hann and Lapworth, *4*, **85**: 1355; 04. (826) Hanriot and Kling, *34*, **152**: 1596; 11. (827) Hardin, *42*, **6**: 584; 08. (828) Hardin and Sikorskii, *42*, **6**: 179; 08. (829) Harding, Walsh and Weizmann, *4*, **99**: 448; 11.

(830) Harnack, *25*, **11**: 2004; 78. (831) Harries and Morrell, *13*, **410**: 70; 15. (832) Harries and Neresheimer, *25*, **41**: 38; 09. (833) Hartmann, *25*, **21**: 221; 88. (834) Hartwall, *25*, **35**: 3399; 02. (835) Harvey, *4*, **87**: 1481; 05. (836) Harvey and Lapworth, *4*, **83**: 1102; 03. (837) Haworth, *4*, **107**: 8; 15. (837.5) Haworth and Fyfe, *4*, **105**: 1659; 14. (838) Haworth and Law, *4*, **109**: 1314; 16. (839) Haworth and Leitch, *4*, **115**: 809; 19.

(840) Haworth and Perkin, *4*, **103**: 2225; 13. (841) Haworth, Perkin and Wallach, *13*, **379**: 131; 11. *4*, **99**: 118; 11. (842) Haworth, Perkin and Wallach, *13*, **399**: 155; 13. *4*, **103**: 1228; 13. (842.5) Haworth and Wylam, *4*, **123**: 3120; 23. (843) Heckel, *57*, **29**: 779; 08. (844) Hedenburg, *1*, **37**: 345; 15. (845) Heikel, *13*, **338**: 71; 05. (846) Hein, *Diss.*, Berlin, 1896. (847) Helbronner, *34*, **133**: 43; 01. (848) Helferich, Löwa, Nipple and Riedel, *25*, **56**: 1083; 23. (849) Henderson and Caw, *4*, **101**: 1416; 12.

(850) Henry and Paget, *4*, **123**: 1878; 23. (851) Hérissey, *49*, **2**: 248; 10. (852) Hérissey and Aubry, *49*, **9**: 327; 14. (853) Herrmann, *53*, **37**: 119; 05. (854) Herrmann and Tollens, *25*, **18**: 1333; 85. (855) Herrmann and Tollens, *13*, **230**: 50; 85. (856) Herzfeld, *25*, **12**: 2120; 79. (857) Herzfeld, *13*, **220**: 206; 83. (857.5) Herzfeld, *13*, **220**: 335; 83. (858) Herzfeld, *13*, **244**: 274; 88. (859) Herzfeld, *25*, **28**: 440; 95.

(860) Herzfeld, *445*, **45**: 234; 95. (861) Herzfeld and Winter, *25*, **19**: 390; 86. (862) Herzig, *25*, **56**: 221; 23. (863) Herzig and Pollak, *57*, **27**: 743; 06. (864) Hesekiel, *25*, **18**: 3091; 85. (865) Hesse, *13*, **166**: 217; 73. (866) Hesse, *13*, **178**: 244; 75. (867) Hesse, *13*, **182**: 128; 76. (868) Hesse, *13*, **185**: 296; 77. (869) Hesse, *25*, **10**: 2149; 77.

(870) Hesse, *13*, **192**: 175; 78. (871) Hesse, *13*, **192**: 193; 78. (871.5) Hesse, *13*, **199**: 333; 79. (872) Hesse, *25*, **13**: 2308; 80. (873) Hesse, *13*, **203**: 144; 80. (874) Hesse, *13*, **205**: 194: 80. (875) Hesse, *13*, **205**: 314; 80. (875.5) Hesse, *25*, **14**: 1683; 81. (876) Hesse, *25*, **14**: 1890; 81. (877) Hesse, *13*, **207**: 288; 81. (878) Hesse, *13*, **209**: 62; 81. (879) Hesse, *13*, **211**: 249; 82.

(880) Hesse, *13*, **214**: 1; 82. (880.5) Hesse, *25*, **15**: 854; 82. (881) Hesse, *25*, **16**: 58; 83. (881.2) Hesse, *13*, **222**: 203; 84. (881.5) Hesse, *13*, **225**: 104; 84. (882) Hesse, *13*, **225**: 211; 84. (883) Hesse, *13*, **227**: 153; 85. (884) Hesse, *25*, **19**: 3190; 86. (885) Hesse, *13*, **234**: 243; 86. (885.5) Hesse, *13*, **176**: 89, 189; 75. (886) Hesse, *13*, **241**: 255; 87. (888) Hesse, *13*, **260**: 213; 90. (888.5) Hesse, *13*, **267**: 138; 92. (889) Hesse, *13*, **267**: 142; 92.

(890, 891) Hesse, *13*, **271**: 100; 92. (892) Hesse, *13*, **271**: 180; 92. (893) Hesse, *13*, **276**: 88; 93. (894) Hesse, *52*, **65**: 91; 02. (895) Hesse, *52*, **66**: 401; 02. (896) Hesse, *25*, **39**: 1127; 06. (897) Hesse, *52*, **77**: 321; 08. (898) Hessen, *Thesis*, Zürich, 1914. *10*, **4**: 584; 21. (899) Heydrich, *94*, **48**: 243; 11.

(900) Hilditch, *4*, **93**: 1; 08. (901) Hilditch, *4*, **93**: 700; 08. (902) Hilditch, *4*, **93**: 1388; 08. (903) Hilditch, *4*, **93**: 1618; 08. (904) Hilditch, *4*, **95**: 331; 09. (905) Hilditch, *4*, **95**: 1570; 09. (906) Hilditch, *4*, **95**: 1578; 09. (907)

Hilditch, *4*, **97**: 1091; 10. (908) Hilditch, *4*, **99**: 218; 11. (908.5) Hilditch, *4*, **99**: 224; 11. (909) Hilditch, *7*, **77**: 482; 11.

(910) Hilditch, *4*, **101**: 192; 12. (911) Hill and Russe, *25*, **37**: 2538; 04. (912) Hirst and Morrison, *4*, **123**: 3226; 23. (913) Hönig and Jesser, *445*, **38**: 1027; 88. (914) Hofmann, *13*, **366**: 277; 09. (914.8) Hohenemser and Wolffenstein, *25*, **32**: 2520; 99. (915) Hohenemser and Wolffenstein, *25*, **34**: 2420; 01. (916) Holmberg, *25*, **45**: 2997; 12. (917) Holmberg, *25*, **47**: 167; 14. (918) Holmberg and Lenander, *19*, **6**: No. 17; 17. (919) Holmberg and Sunesson, *519*, **35**: 215; 23.

(920) Holty, *50*, **9**: 764; 05. (920.2) Holmberg, *19*, **6**: No. 1; 17. (920.5) Holmberg, *19*, **6**: No. 23; 17. (921) Hoogewerff and Dorp, *70*, **14**: 252; 95. (922) Hopkins and Savory, *289*, **42**: 189; 11. (923) Hoppe-Seyler, *52*, **89**: 257; 63. (924) Hoppe-Seyler and Araki, *202*, **20**: 365; 95. (925) Hoppe-Seyler and Thierfelder, *Handbuch der physiologisch- und pathologisch-chemischen Analyse.* 6th ed. Berlin, 1893. (926) Horrmann, *25*, **45**: 2090; 12. (927) Horrmann, *25*, **45**: 3434; 12. (928) Horrmann, *25*, **46**: 2793; 13. (929) Horrmann, *13*, **411**: 273; 16.

(930) Horrmann and Seydel, *25*, **45**: 3080; 12. (931) Horrmann and Wachter, *25*, **49**: 1554; 16. (932) Houben and Willfroth, *25*, **46**: 2283; 13. (933) Hoving, *Diss.*, Groningen, 1911. *10*, **4**: 656; 21. (934) Howard and Chick, *54*, **28**: 53; 09. (935) Howard and Hodgkin, *4*, **41**: 66; 82. (936) Huber, *Thesis*, Geneva, 1916. *10*, **4**: 1092; 21. (937) Hudson, *1*, **37**: 1591; 15. (938) Hudson, *1*, **38**: 1566; 16. (939) Hudson and Brauns, *1*, **37**: 1283; 15.

(940) Hudson and Brauns, *1*, **37**: 2736; 15. (941) Hudson and Brauns, *1*, **38**: 1216; 16. (942) Hudson and Dale, *1*, **37**: 1264; 15. (943) Hudson and Dale, *1*, **37**: 1280; 15. (944) Hudson and Dale, *1*, **38**: 1431; 16. (945) Hudson and Johnson, *1*, **37**: 1270; 15. (946) Hudson and Johnson, *1*, **37**: 1276; 15. (947) Hudson and Johnson, *1*, **38**: 1223; 16. (948) Hudson and Munroe, *1*, **46**: 979; 24. (949) Hudson and Parker, *1*, **37**: 1589; 15.

(950) Hudson and Sayre, *1*, **38**: 1867; 16. (951) Hudson and Yanovsky, *1*, **38**: 1575; 16. (952) Hüni, *Thesis*, Suisse, 1910. *10*, **1**: 589; 12. (953) Hürlimann, *Thesis*, Zürich, 1918. *10*, **5**: 727; 25. (954) Hürthle, *202*, **21**: 337; 96. (955) Huppert, *202*, **18**: 137; 94. (956) Iljin, *25*, **47**: 985; 14. (957) Imbert, *27*, **27**: 985; 02. (958) Ingersoll, *2*, **9**: 257; 17. (959) Ipatiev, *25*, **45**: 3205; 12.

(960) Irvine, *4*, **95**: 564; 09. (961) Irvine and Cameron, *4*, **85**: 1071; 04. (962) Irvine, Fyfe and Hogg, *4*, **107**: 524; 15. (963) Irvine and Garrett, *4*, **97**: 1277; 10. (964) Irvine and Gilmour, *4*, **93**: 1429; 08. (965) Irvine and Gilmour, *4*, **95**: 1545; 09. (966) Irvine and Hogg, *4*, **105**: 1386; 14. (967) Irvine and Hynd, *4*, **95**: 1220; 09. (968) Irvine and Hynd, *4*, **99**: 161; 11. (969) Irvine and Hynd, *4*, **101**: 1128; 12.

(970) Irvine and Hynd, *182*, **29**: 306; 13. (971) Irvine and Hynd, *4*, **103**: 41; 13. (972) Irvine and Hynd, *4*, **105**: 698; 14. (973) Irvine and MacDonald, *4*, **107**: 1701; 15. (974) Irvine, MacDonald and Soutar, *4*, **107**: 337; 15. (975) Irvine and McNicoll, *4*, **97**: 1449; 10. (976) Irvine, McNicoll and Hynd, *4*, **99**: 250; 11. (977) Irvine and Moodie, *4*, **87**: 1462; 05. (978) Irvine and Moodie, *4*, **89**: 1578; 06. (979) Irvine and Paterson, *133*, **1912**: 441.

(980) Irvine and Paterson, *4*, **105**: 898; 14. (981) Irvine and Robertson, *4*, **109**: 1305; 16. (982) Irvine and Rose, *4*, **89**: 814; 06. (983) Irvine and Scott, *133*, **1912**: 442. (984) Irvine and Scott, *4*, **103**: 564; 13. (985) Irvine and Scott, *4*, **103**: 575; 13. (986) Irvine and Steele, *4*, **107**: 1221; 15. (987) Irvine, Thomson and Garrett, *4*, **103**: 238; 13. (988) van Itallie, *64V*, **20**: 1024; 12. (989) Itzig, *25*, **34**: 1372; 01.

(990) Itzig, *25*, **34**: 2391; 01. (991) Jackson, *31A*, **13**: 633; 17. (992) Jacobi, *25*, **24**: 696; 91. (993) Jacobi, *13*, **272**: 170; 93. (994) Jacobi and Stoehr, *25*, **26**: 949; 93. (995) Jacobs, *141*, **57**: 553; 23. (996) Jaeger, *64P*, **17**: 1217; 15. (997) Jaeger, *64V*, **26**: 152; 17. (998) Jaeger, *70*, **38**: 171; 19. (999) Jaeger and Thomas, *64V*, **27**: 674; 18.

(1000) Jaeger and Thomas, *64P*, **21**: 215; 18. (1000.5) Jaeger and Thomas, *64P*, **21**: 225; 18. (1001) Jaeger and Wolderdorp, *64V*, **27**: 1212; 18. (1002) Jephcott, *4*, **115**: 104; 19. (1003) Jobst and Hesse, *13*, **178**: 49; 75. (1004) Jobst and Hesse, *13*, **199**: 17; 79. (1005) Jones, *4*, **83**: 1400; 03. (1006) Jones, *4*, **85**: 223; 04. (1007) Jones, *4*, **87**: 135; 05. (1008) Jones and Dunlop, *4*, **101**: 1748; 12. (1009) Jones and Hill, *4*, **93**: 295; 08.

(1010) Jones and Millington, *201*, **12**: 489; 04. (1011) de Jong, *70*, **42**: 980; 23. (1012) Jowett, *135*, **74**: 120; 96. (1013) Jowett, *4*, **77**: 473; 00. (1014) Jowett, *4*, **77**: 851; 00. (1015) Jowett, *4*, **79**: 580; 01. (1015.5) Jowett, *4*, **79**: 1331; 01. (1016) Jowett and Pyman, *4*, **103**: 290; 13. (1017) Jürgens, *167*, **1885**: 1722. *498*, **24**: 721, 745, 762, 778, 794; 85. (1018) Jungfleisch, *34*, **110**: 790; 90. (1019) Jungfleisch and Godchot, *34*, **140**: 719; 05.

(1020) Jungfleisch and Godchot, *34*, **141**: 111; 05. (1021) Jungfleisch and Godchot, *34*, **142**: 637; 06. (1022) Jungfleisch and Grimbert, *34*, **107**: 390; 88. (1023) Jungfleisch and Leger, *34*, **105**: 1255; 87. (1024) Jungfleisch and Leger, *34*, **106**: 357; 88. (1025) Jungfleisch and Leger, *34*, **106**: 657; 88. (1026) Jungfleisch and Leger, *27*, **49**: 743; 88. (1027) Jungfleisch and Leger, *34*, **108**: 952; 89. (1028) Jungfleisch and Leger, *34*, **114**: 1192; 92. (1029) Jungfleisch and Leger, *34*, **118**: 29; 94.

(1030) Jungfleisch and Leger, *34*, **119**: 1268; 94. (1031) Jungfleisch and Leroux, *34*, **144**: 1435; 07. (1032) Jungfleisch and Leroux, *34*, **147**: 862; 08. (1033) Just, *13*, **220**: 146; 83. (1034) Kachler, *13*, **197**: 86; 79. (1035) Kallenberg, *25*, **56**: 316; 23. (1036) Karpf, *Thesis*, Zürich, 1915. *10*, **4**: 584; 21. (1037) Karrer, *25*, **49**: 1644; 16. (1038) Karrer and Kaase, *37*, **2**: 436; 19. (1039) Karrer, Salmon and Peyer, *37*, **6**: 3; 23.

(1040) Karrer and Schlosser, *37*, **6**: 411; 23. (1041) Karrer, Widmer and Staub, *13*, **433**: 288; 23. (1042) Karrer and Zega, *37*, **6**: 822; 23. (1043) Kaufmann, *25*, **46**: 1823; 13. (1044) Kaufmann and Fuchs, *25*, **56**: 2527; 23. (1045) Kaufmann and Huber, *25*, **46**: 2913; 13. (1046) Kay, *13*, **362**: 325; 08. (1047) Kay, *4*, **95**: 560; 09. (1048) Kay and Perkin, *4*, **89**: 839; 06. (1048.5) Kazay, *515*, **24**: 23; 20. (1049) Kelch, *Thesis*, Zürich, 1912. *10*, **4**: 584; 21.

(1050) Kent and Tollens, *25*, **17**: 668; 84. (1051) Kenyon, *4*, **105**: 2226; 14. (1052) Kenyon and McNicol, *4*, **123**: 14; 23. (1052.5) Kenyon and Pickard, *4*, **105**: 2262; 14. (1053) Kenyon and Pickard, *4*, **105**: 2644; 14. (1054) Kenyon and Pickard, *4*, **105**: 2677; 14. (1055) Kenyon and Pickard, *4*, **107**: 35; 15. (1056) Kenyon and Pickard, *4*, **107**: 115; 15. (1057) Kiliani, *25*, **15**: 2953; 82. (1058) Kiliani, *25*, **16**: 2625; 83. (1059) Kiliani, *25*, **19**: 767; 86.

(1060) Kiliani, *25*, **19**: 1914; 86. (1061) Kiliani, *25*, **19**: 3029; 86. (1062) Kiliani, *25*, **24**: 339; 91. (1063) Kiliani, *25*, **25**: 2116; 92. (1064) Kiliani, *293*, **234**: 438; 96. (1065) Kiliani and Matthes, *25*, **40**: 1238; 07. (1066) Kiliani and Sanda, *25*, **26**: 1649; 93. (1067) Kiliani and Sautermeister, *25*, **40**: 4294; 07. (1068) King, *Thesis*, Zürich, 1912. *10*, **4**: 584; 21. (1069) Kipping, *4*, **77**: 861; 00.

(1070) Kipping, *4*, **79**: 370; 01. (1071) Kipping, *4*, **81**: 275; 02. (1072) Kipping, *4*, **93**: 457; 08. (1073) Kipping, *4*, **95**: 408; 09. (1074) Kipping and Challenger, *4*, **99**: 626; 11. (1075) Kipping and Davies, *4*, **95**: 69; 09. (1076) Kipping and Hall, *4*, **79**: 430; 01. (1077) Kipping and Hall, *4*, **79**: 442; 01. (1078) Kipping and Hunter, *4*, **81**: 574; 02. (1079) Kipping and Hunter, *4*, **83**: 1005; 03.

(1080) Kipping and Pope, *4*, **63**: 548; 93. (1081) Kipping and Salway, *4*, **85**: 438; 04. (1082) Kižer, *53*, **31**: 872; 99. (1083) Kižer, *53*, **39**: 1240; 07. (1084) Kižer, *53*, **39**: 1246; 07. (1085) Kizhner, *53*, **43**: 582; 11. (1086) Kizhner, *53*, **43**: 1554; 11. (1087) Kizhner and Zavadovskii, *53*, **43**: 1132; 11. (1088) Klages, *25*, **39**: 2131; 06. (1089) Klages, *25*, **29**: 2306; 06.

(1090) Klages, *25*, **40**: 2360; 07. (1091) Klages and Sautter, *25*, **37**: 649; 04. (1092) Klages and Sautter, *25*, **38**: 2312; 05. (1093) Klages and Sautter, *25*, **39**: 1938; 06. (1094) Klason and Köhler, *19*, **2**: No. 3; 05. (1095) Klimenko, *53*, **12**: 17; 80. (1096) Klobb, *27*, **27**: 1229; 02. (1097) Klobb, *34*, **148**: 1272; 09. (1098) Klobb, *6*, **22**: 5; 11. (1099) Klobb, *6*, **24**: 134; 11.

(1100) Klobb, *6*, **24**: 410; 11. (1101) Knoevenagel and Samel, *25*, **39**: 677; 06. (1102) Knorr, *25*, **27**: 1144; 94. (1103) Knorr, *25*, **37**: 3172; 04. (1104) Knorr, Butler and Hörlein, *13*, **368**: 305; 09. (1105) Knorr and Hartmann, *25*, **45**: 1350; 12. (1106) Knorr and Hawthorne, *25*, **35**: 3010; 02. (1107) Knorr and Hörlein, *25*, **40**: 2032; 07. (1108) Knorr and Hörlein, *25*, **40**: 4883; 07. (1109) Knorr and Hörlein, *25*, **40**: 4889; 07.

(1110) Knorr, Hörlein and Grimme, *25*, **40**: 3844; 07. (1111) Knorr, Hörlein and Staubach, *25*, **42**: 3511; 09. (1112) Knorr, Hörlein and Staubach, *25*, **42**: 3521; 09. (1113) Knorr and Raabe, *25*, **41**: 3050; 08. (1114) Knorr and Smiles, *25*, **35**: 3009; 02. (1115) Knorr and Waentig, *25*, **40**: 3860; 07. (1117) Koenigs, *13*, **347**: 143; 06. (1118) Koenigs and Knorr, *25*, **34**: 957; 01. (1119) Koenigs and Knorr, *25*, **23**: 4343; 01.

(1120) Koenigs and Mylo, *25*, **41**: 4427; 08. (1120.5) Körner and Vanzetti, *Mem. accad. Linc.*, **8**: 749; 11. (1121) Kötz and Schwarz, *13*, **357**: 209; 07. (1122) Kolm, *57*, **33**: 447; 12. (1123) Komatsu, *429*, **1**: 123; 15. (1124) Komppa and Hintikka, *25*, **46**: 645; 13. (1125) Kondakov, *136*, **26**: 720; 02. (1126) Kondakov, *52*, **67**: 280; 03. (1127) Kondakov, *52*, **79**: 271; 09. (1128) Kondakov and Lučinin, *52*, **60**: 257; 99. (1129) Kondakov and Schindelmeiser, *52*, **67**: 193; 03.

(1130) Kondakov and Schindelmeiser, *52*, **68**: 105; 03. (1131) Kondakov and Skworzov, *52*, **67**: 573; 03. (1132) Konowalov, *53*, **36**: 237; 04. (1133) Kossel and Kutscher, *202*, **28**: 382; 99. (1134) Krafft and Dyes, *25*, **28**: 2589; 95. (1135) Kraft, *516*, **33**: 205; 10. (1135.5) Krecke, *18*, **7**: 97; 72. (1136) van Kregten, *Diss.*, Groningen, 1910. *10*, **1**: 589; 10. (1137) Kritzmann, *Thesis*, Zürich, 1919. *10*, **5**: 727; 22. (1138) Krusemann, *25*, **9**: 1465; 76. (1138.4) Külz, *145*, **20**: 1; 84. (1138.4) Külz, *Arch. expt. Pathol.*, **18**: 291; 84. (1138.6) Külz, *145*, **20**: 165; 84. (1138.8) Külz, *145*, **23**: 474; 87. (1139) Küng and Trier, *202*, **85**: 209; 13.

(1140) Küster and Hügel, *202*, **130**: 1; 23. (1141) Kuhn, *25*, **56**: 857; 23. (1142) Kuntner, *Thesis*, Zürich, 1913. *10*, **4**: 584; 21. (1143) Kuriloff, *52*, **45**: 123; 92. (1144) Kursanov, *53*, **53**: 289; 01. (1145) Lacroix, *49*, **22**: 99; 05. (1146) Lacroix, *49*, **24**: 493; 06. (1147) Ladenburg, *13*, **247**: 1; 88. (1148) Ladenburg, *25*, **21**: 3065; 88. (1149) Ladenburg, *25*, **26**: 854; 93.

(1150) Ladenburg, *25*, **27**: 75; 94. (1151) Ladenburg, *25*, **27**: 853, 3063; 94. (1152) Ladenburg, *25*, **29**: 2710; 96. (1153) Ladenburg, *25*, **36**: 3694; 03. (1154) Ladenburg, *25*, **37**: 3688; 04. (1155) Ladenburg, *25*, **40**: 3734; 07. (1156) Ladenburg and Herrmann, *25*, **41**: 966; 08. (1157) Ladenburg and Hundt, *25*, **22**: 2590; 89. (1158) Lafont, *6*, **15**: 145; 98. (1158.5) Lafont, *27*, **49**: 323; 88. (1159) La Forge, *141*, **28**: 511; 17.

(1160) Landolt, *25*, **6**: 1073; 73. (1161) Landolt, *13*, **189**: 241; 77. (1162) Landolt, *Das optische Drehungsvermögen.* Braunschweig, 1st ed., 1879; 2nd ed., 1898. (1162.5) Landolt, *25*, **13**: 2329; 80. (1163) Landolt, *25*, **19**: 157; 86. (1164) Landolt, *25*, **21**: 191; 88. (1165) Landwehr, *202*, **8**: 165; 84.

(1166) Langheld, *25*, **41**: 378; 08. (1167) Lapworth, *4*, **77**: 1053; 00. (1168) Lapworth, *4*, **83**: 1114; 03. (1169) Lapworth, *4*, **89**: 945; 06.

(1170) Lapworth, *4*, **89**: 1819; 06. (1171) Lapworth and Hann, *4*, **81**: 1499; 02. (1172) Lapworth and Hann, *4*, **81**: 1508; 02. (1173) Lapworth and Harvey, *4*, **81**: 549; 02. (1174) Lapworth and Steele, *4*, **99**: 1877; 11. (1175) Lapworth and Wechsler, *4*, **91**: 977; 07. (1176) Lapworth and Wechsler, *4*, **97**: 38; 10. (1177) Latschinoff, *25*, **13**: 1052; 80. (1178) Latschinoff, *25*, **19**: 474; 86. (1179) Leach, *4*, **87**: 413; 05.

(1180) Le Bel, *34*, **77**: 1021; 73. (1181) Le Bel, *27*, **21**: 542; 74. (1182) Le Bel, *27*, **25**: 545; 76. (1183) Lees, *4*, **85**: 639; 04. (1184) Lees, *4*, **91**: 1408; 07. (1185) Lefebure, *49*, **26**: 241; 07. (1186) Léger, *34*, **111**: 109; 90. (1187) Léger, *34*, **117**: 110; 93. (1188) Léger, *34*, **155**: 172; 12. (1189) Léger, *34*, **158**: 1189; 14.

(1190) Léger, *34*, **162**: 506; 16. (1191) Léger and Roques, *34*, **155**: 1088; 12. (1192) Léger and Roques, *34*, **156**: 1687; 13. (1193) Lehrfeld, *Thesis*, Zürich, 1915. *10*, **4**: 584; 21. (1194) Lellmann, *13*, **259**: 193; 90. (1195) Lendrich, Kock and Schwarz, *279*, **22**: 441; 11. (1196) Lenz, *91*, **27**: 549; 88. (1197) Leone and d'Emilio, *36*, **40 I**: 556; 10. (1198) Lepëkin, *53*, **40**: 698; 08. (1199) Leroide, *34*, **148**: 1611; 09.

(1200) Leser, *27*, **25**: 196; 01. (1201) Le Sueur, *4*, **93**: 716; 08. (1202) Le Sueur, *4*, **103**: 2108; 13. (1203) Letsche, *202*, **60**: 462; 09. (1204) Leuchs, *25*, **41**: 1711; 08. (1205) Leuchs, *25*, **46**: 2435; 13. (1206) Leuchs, *25*, **48**: 1015; 15. (1207) Leuchs and Brewster, *25*, **45**: 201; 12. (1208) Leuchs and Brewster, *25*, **46**: 986; 13. (1209) Leuchs and Gladkorn, *25*, **56**: 1780; 23.

(1210) Leuchs, Gladkorn and Hellriegel, *25*, **56**: 2472; 23. (1211) Leuchs and Greiger, *25*, **42**: 3067; 09. (1212) Leuchs and Rauch, *25*, **46**: 3917; 13. (1213) Leuchs and Rauch, *25*, **47**: 370; 14. (1214) Leuchs and Schneider, *25*, **42**: 2494; 09. (1215) Leuchs and Schneider, *25*, **42**: 2681; 09. (1216) Leuchs and Weber, *25*, **42**: 770; 09. (1217) Leuchs and Wutke, *25*, **45**: 3686; 12. (1218) Leuchs and Wutke, *25*, **46**: 2420; 13. (1219) Leuckart and Bach, *25*, **20**: 104; 87.

(1220) Levene, *141*, **24**: 59; 16. (1220.5) Levene, *141*, **24**: 69; 16. (1221) Levene, *141*, **26**: 143; 16. (1222) Levene, *141*, **26**: 155; 16. (1223) Levene, *141*, **26**: 367; 16. (1224) Levene, *141*, **57**: 323; 23. (1225) Levene, *141*, **57**: 337; 23. (1226) Levene, *141*, **59**: 123; 24. (1227) Levene, *141*, **59**: 135; 24. (1228) Levene, *141*, **59**: 141; 24. (1229) Levene and Jacobs, *25*, **42**: 2102; 09.

(1230) Levene and Jacobs, *25*, **42**: 3247; 09. (1231) Levene and La Forge, *25*, **45**: 608; 12. (1232) Levene and La Forge, *141*, **15**: 155; 13. (1233) Levene and La Forge, *141*, **15**: 481; 13. (1234) Levene and Meyer, *141*, **26**: 355; 16. (1235) Levene and Meyer, *141*, **55**: 221; 23. (1236) Levene and Meyer, *141*, **57**: 319; 23. (1237) Levene and Meyer, *141*, **59**: 145; 24. (1238) Levene and Mikeska, *141*, **55**: 795; 23. (1239) Levene and West, *141*, **26**: 115; 16.

(1240) Levy and Wolffenstein, *25*, **28**: 2270; 95. (1241) Levy and Wolffenstein, *25*, **29**: 1960; 96. (1242) Lewkowitsch, *25*, **16**: 1568; 83. (1243) Lewkowitsch, *25*, **16**: 2720; 83. (1244) Lewkowitsch, *25*, **17**: 1439; 84. (1245) Liebermann, *25*, **21**: 2342; 88. (1245.5) Liebermann, *25*, **24**: 606; 91. (1246) Liebermann, *25*, **40**: 3602; 07. (1247) Liebermann and Giesel, *25*, **23**: 926; 90. (1248) Liebermann and Hörmann, *25*, **11**: 952; 78. (1249) Lifschitz, *7*, **105**: 27; 23.

(1250) Likiernik, *202*, **15**: 415; 90. (1251) Lindenmeyer, *52*, **90**: 321; 63. (1252) Lintner and Düll, *92*, **1892**: 263. (1253) Lintner and Düll, *516*, **17**: 339; 94. (1254) Lintner and Liebig, *202*, **88**: 109; 13. (1255) Lipp, *13*, **382**: 265; 11. (1256) Lipp, *13*, **339**: 241; 13. (1256.5) Lipp, *25*, **56**: 2098; 23. (1257) Lippmann, *13*, **219**: 173; 83. (1258) Lippmann, *25*, **17**: 2239; 84. (1259) Lippmann, *25*, **17**: 2835; 84.

(1260) Lippmann, *25*, **20**: 1001; 87. (1261) Lippmann, *25*, **28**: 1971; 95. (1262) Lobry de Bruyn and van Ekenstein, *70*, **20**: 331; 01. (1262.5) Lobry de Bruyn and van Ekenstein, *70*, **21**: 310; 02. (1263) Lobry de Bruyn and van Ekenstein, *25*, **35**: 3079; 02. (1264) Lobry de Bruyn and van Ekenstein, *64P*, **5**: 175; 02. (1265) Locquin, *27*, **1**: 595; 07. (1266) Löffler, *25*, **37**: 1879; 04. (1267) Löffler and Grunert, *25*, **40**: 1342; 07. (1268) Löffler and Kirschner, *25*, **38**: 3329; 05. (1269) Löffler and Tschunke, *25*, **42**: 929; 09.

(1270) Loiseau, *34*, **82**: 1058; 76. (1271) Long, *12*, **36**: 351; 88. (1272) Long, *12*, **38**: 264; 89. (1273) Long, *12*, **40**: 275; 90. (1274) Long, *1*, **14**: 149; 92. (1275) Long, *J. Anal. Appl. Chem.*, **7**: 99; 93. (1276) Long, *1*, **21**: 637; 99. (1277) Long, *1*, **23**: 813; 01. (1278) Long, *1*, **27**: 363; 05. (1279) Longchambon, *34*, **175**: 174; 22.

(1280) Longchambon, *34*, **178**: 951; 24. (1281) Louvrier, *Thesis*, Paris, 1910. *10*, **4**: 589; 21. *14*, **9**: 189; 18. (1283) Lovén, *52*, **78**: 63; 08. (1284) Lovén and Ohlsson, *25*, **47**: 1534; 14. (1285) Lowry, *4*, **73**: 569; 98. (1285.5) Lowry, *4*, **73**: 986; 98. (1286) Lowry, *4*, **75**: 211; 99. (1286.5) Lowry, *4*, **83**: 953; 03. (1287) Lowry, *4*, **85**: 1551; 04. (1288) Lowry, *5*, **81**: 472; 08. (1289) Lowry, *133*, **1912**: 419.

(1290) Lowry, *4*, **103**: 1062; 13. (1291) Lowry, *62*, **212**: 261; 13. (1292) Lowry, *4*, **107**: 1195; 15. (1293) Lowry and Abram, *4*, **107**: 1187; 15. (1294) Lowry and Austin, *5*, **222**: 249; 22. (1295) Lowry and Burgess, *4*, **123**: 2111; 23. (1296) Lowry and Courtman, *4*, **103**: 1214; 13. (1297) Lowry and Cutter, *4*, **121**: 532; 22. (1298) Lowry and Dickson, *4*, **103**: 1067; 13. (1299) Lowry and Dickson, *83*, **10**: 96; 14.

(1300) Lowry and Dickson, *4*, **107**: 1173; 15. (1301) Lowry and Donington, *4*, **83**: 479; 03. (1302) Lowry and Glover, *4*, **103**: 913; 13. (1302.5) Lowry and Magson, *4*, **89**: 1042; 06. (1303) Lowry and Magson, *4*, **93**: 107; 08. (1304) Lowry and Magson, *4*, **93**: 119; 08. (1305) Lowry, Pickard and Kenyon, *4*, **105**: 94; 14. (1306) Lowry and Robertson, *4*, **85**: 1541; 04. (1307) Lowry and Steele, *182*, **30**: 201; 14. (1308) Lowry and Steele, *4*, **107**: 1038; 15. (1309) Lowry and Steele, *4*, **107**: 1382; 15.

(1310) Lowry, Steele and Burgess, *4*, **121**: 633; 22. (1311) Luff and Kipping, *4*, **93**: 2090; 08. (1311.5) Luff and Kipping, *4*, **95**: 1993; 09. (1312) Luff and Perkin, *4*, **99**: 518; 11. (1313) Lustgarten, *57*, **2**: 626; 81. (1313.5) Lutz, *Diss.*, Rostock, 1899. (1314) Lutz, *25*, **35**: 2460; 02. (1315) Lutz, *25*, **37**: 2123; 04. (1316) Lutz, *52*, **70**: 1; 04. (1317) Lutz, *25*, **41**: 841; 08. (1318) Lutz, *7*, **70**: 256; 10. (1319) McCrae, *4*, **79**: 1103; 01.

(1320) McCrae, *4*, **81**: 1221; 02. (1321) McCrae, *4*, **83**: 1324; 03. (1322) McCrae and Patterson, *4*, **77**: 1096; 00. (1323) MacDonald, *4*, **103**: 1896; 13. (1324) Mach, *57*, **15**: 627; 94. (1324.2) Macheleidt in Wallach, *13*, **270**: 171; 92. (1324.5) MacKenzie, *4*, **75**: 964; 99. (1325) McKenzie, *4*, **81**: 1402; 02. (1326) McKenzie, *4*, **85**: 1249; 04. (1327) McKenzie, *4*, **89**: 365; 06. (1328) McKenzie, *182*, **27**: 150; 11. (1329) McKenzie, *4*, **101**: 1196; 12.

(1330) McKenzie and Barrow, *4*, **99**: 1910; 11. (1331) McKenzie and Bate, *4*, **107**: 1681; 15. (1332) McKenzie and Clough, *4*, **93**: 811; 08. (1333) McKenzie and Clough, *4*, **95**: 777; 09. (1334) McKenzie and Clough, *4*, **97**: 1016; 10. (1335) McKenzie and Clough, *4*, **97**: 2564; 10. (1336) McKenzie and Clough, *4*, **101**: 390; 12. (1337) McKenzie and Clough, *4*, **103**: 687; 13. (1338) McKenzie, Drew and Martin, *4*, **107**: 26; 15. (1339) McKenzie and Ghosh, *68*, **35**: 22; 15.

(1340) MacKenzie and Ghosh, *68*, **36**: 204; 17. (1341) McKenzie and Humphries, *4*, **95**: 1105; 09. (1342) McKenzie and Humphries, *4*, **97**: 121; 10. (1343) McKenzie and Martin, *4*, **103**: 112; 13. (1344) McKenzie, Martin and Rule, *4*, **105**: 1583; 14. (1344.5) McKenzie and Müller, *4*, **95**: 544; 09. (1345) McKenzie and Plenderleith, *4*, **123**: 1090; 23. (1346) McKenzie and Smith, *4*, **123**: 1962; 23. (1347) McKenzie and Thompson, *4*, **87**: 1004; 05. (1348) McKenzie and Thompson, *4*, **91**: 789; 07. (1349) McKenzie and Walker, *4*, **107**: 1685; 15.

(1350) McKenzie and Widdows, *4*, **107**: 702; 15. (1351) McKenzie and Wood, *4*, **115**: 828; 19. (1352) McKenzie and Wren, *4*, **89**: 688; 06. (1353) McKenzie and Wren, *4*, **91**: 1215; 07. (1354) McKenzie and Wren, *4*, **93**: 309; 08. (1355) McKenzie and Wren, *4*, **97**: 473; 10. (1356) McKenzie and Wren, *4*, **97**: 1355; 10. (1357) McKenzie and Wren, *4*, **117**: 680; 20. (1357.5) Magnus-Levy, *205*, **2**: 319; 07. (1358) Magnus-Levy, *205*, **6**: 502; 07. (1359) Mahla, *25*, **34**: 3777; 01.

(1360) Mahlberg, *Akad. Afhand. Upsal.*, **1914.** *10*, **4**: 1092; 21. (1361) de Mallemann, *34*, **172**: 150; 21. (1362) de Mallemann, *34*, **173**: 474; 22. (1363) de Mallemann, *51*, **4**: 18; 23. (1364) Malosse, *34*, **153**: 54; 11. (1365) Malosse, *27*, **15**: 358; 14. (1366) Mameli, *36*, **37 II**: 483; 07. (1367) Mameli, *36*, **42 II**: 546; 12. (1368) Manasse, *25*, **35**: 3811; 02. (1369) Maquenne, *34*, **106**: 286; 88.

(1370) Maquenne, *34*, **109**: 812; 89. (1371) Maquenne, *34*, **109**: 968; 89. (1372) Maquenne, *34*, **130**: 1402; 00. (1373) Maquenne, *27*, **23**: 587; 00. (1374) Maquenne and Bertrand, *34*, **132**: 1419; 01. (1375) Maquenne and Goodwin, *27*, **31**: 1075; 04. (1376) Marckwald, *25*, **35**: 1602; 02. (1377) Marckwald, *25*, **37**: 1038; 04. (1378) Marckwald and Karzag, *25*, **42**: 1518; 09. (1379) Marckwald and McKenzie, *25*, **34**: 485; 01.

(1380) Marckwald and Meth, *25*, **38**: 801; 05. (1381) Marckwald and Meth, *25*, **39**: 1171; 06. (1382) Marino-Zuco and Pasquero, *36*, **41 II**: 368; 11. (1383) Marko, *13*, **362**: 333; 08. (1384) Markovnikov, *53*, **35**: 226; 03. (1385) Markovnikov and Reformatzky, *52*, **48**: 293; 93. (1386) Markovnikov and Stadnikov, *53*, **35**: 389; 03. (1387) Marquis, *498*, **16**: 449, 481, 513; 77. (1388) Marsh, *135*, **60**: 307; 89. (1389) Marsh, *4*, **57**: 828; 90.

(1390) Marsh and Cousins, *4*, **59**: 966; 91. (1391) Marsh and Gardner, *4*, **65**: 35; 94. (1392) Marsh and Gardner, *135*, **74**: 279; 96. (1393) Marsh and Struthers, *4*, **95**: 1777; 09. (1394) Martine, *34*, **134**: 1437; 02. (1395) Martine, *6*, **9**: 49; 04. (1396) Mascarelli, *36*, **45 I**: 127; 15. (1397) Mascarelli and Nigrisali, *22*, **23 II**: 276; 14. (1398) Mascarelli and Nigrisali, *36*, **45 I**: 106; 15. (1399) Masson, *345*, **18**: 283, 477; 11.

(1400) Masson, *34*, **154**: 517; 12. (1401) Mauthner, *57*, **3**: 343; 83. (1401.5) Mauthner, *202*, **7**: 222; 83. (1402) Mauthner, *57*, **27**: 421; 06. (1403) Mauthner, *57*, **28**: 1113; 07. (1404) Mauthner, *57*, **30**: 635; 09. (1404.5) Mauthner, *144*, **31**: 89; 13. (1404.8) Mauthner, *144*, **32**: 000; 14. (1405) Mayer, *205*, **1**: 39; 06. (1406) Mayer, *205*, **9**: 439; 08. (1407) Mayer, *205*, **17**: 145; 09. (1408) Mayer and Tollens, *25*, **40**: 2434; 07. (1409) Mazzucchelli, Ranucci and Sabatini, *36*, **43 II**: 26; 14.

(1410) Mazzucchelli and Sabatini, *36*, **45 II**: 225; 15. (1411) Meerwein and Gerard, *13*, **435**: 174; 23. (1411.5) Meisenheimer, *13*, **385**: 117; 11. (1412) Meisenheimer and Lichtenstadt, *25*, **44**: 356; 11. (1413) Meissl, *52*, **22**: 97; 80. (1414) Menozzi and Appiani, *36*, **22 II**: 105; 92. (1416) Menozzi and Appiani, *22*, **2**: 415; 93. (1416) Menozzi and Moreschi, *22*, **17 I**: 95; 08. (1417) Merck, *293*, **229**: 161; 91. (1418) Merck, *293*, **231**: 117; 93. (1419) Meulenhoff, *Nederl. Tijdsch. Pharm.*, **5**: 258. *185*, **1893 II**: 761.

(1420) Meyer, *202*, **6**: 135; 82. (1421) Meyer, *9*, **13**: 494; 07. (1422) Michael, *25*, **14**: 2105; 81. (1423) Michaud, *135*, **53**: 232; 86. (1424) Mills and

Bain, *4*, **97**: 1866; 10. (1425) Mills, Parker and Prowse, *4*, **105**: 1537; 14. (1426) Mills, Parker and Prowse, *201*, **17**: 478; 14. (1427) Mills and Schindler, *4*, **123**: 312; 23. (1428) Milohendski, *53*, **39**: 1395; 07. (1429) Minguin, *34*, **112**; 1369; 91.

(1430) Minguin, *34*, **116**: 889; 93. (1431) Minguin, *34*, **130**: 510; 00. (1431.5) Minguin, *34*, **136**: 751; 03. (1432) Minguin, *34*, **137**: 1067; 03. (1433) Minguin, *34*, **138**: 577; 04. (1434) Minguin, *34*, **140**: 946; 05. (1435) Minguin, *34*, **146**: 287; 08. (1436) Minguin, *6*, **25**: 145; 12. (1437) Minguin, *14*, **9**: 3, 367; 15. (1438) Minguin and Bloc, *34*, **158**: 1273; 14. (1439) Minguin and Bloc, *34*, **158**: 1997; 14.

(1440) Minguin and de Bollement, *34*, **136**: 238; 03. (1440.5) Minkowski, *Arch. exp. Path.*, **18**: 35, 147; 84. (1441) Mitscherlich, *52*, **73**: 65; 58. (1442) Möller, *519*, **28**: 123; 16. (1443) Molby, *2*, **30**: 77; 10. (1444) Monnet and Barbier, *34*, **117**: 1092; 93. (1445) Montemartini and Bovini, *36*, **46 I**: 153; 16. (1446) Montgolfier, *34*, **84**: 88; 77. (1447) Montgolfier, *34*, **85**: 286; 77. (1448) Montgolfier, *27*, **28**: 414; 77. (1449) Montgolfier, *6*, **14**: 5; 78.

(1450) Montgolfier, *34*, **89**: 101; 79. (1451) Moore, *4*, **97**: 1797; 10. (1452) Moore, *4*, **97**: 2223; 10. (1453) Moore, *182*, **26**: 182; 10. (1454) Moore, *4*, **99**: 416; 11. (1455) Moore, *4*, **99**: 1231; 11. (1455.5) Moreschi, *22*, **19 II**: 53; 10. (1456) Morgan and Hickinbottom, *4*, **123**: 97; 23. (1457) Morgan and Micklethwait, *4*, **93**: 2144; 08. (1458) Morgan, Micklethwait and Whitby, *4*, **97**: 34; 10. (1459) Morgan and Moore, *4*, **97**: 1697; 10.

(1460) Morgenstern, *57*, **33**: 709; 12. (1461) Morin, *34*, **92**: 998; 81. (1462) Morrel and Hanson, *4*, **85**: 197; 04. (1463) Mossler, *57*, **28**: 1029; 07. (1464) Mossler, *57*, **31**: 1; 10. (1465) Mossler, *57*, **33**: 19; 12. (1466) Mossler and Tschebull, *25*, **44**: 105; 11. (1467) Mossowitsch, *Thesis*, Zürich, 1912. (1468) Moureu and Valeur, *34*, **145**: 815; 07. (1469) Moureu and Valeur, *34*, **145**: 929; 07.

(1470) Moureu and Valeur, *34*, **145**: 1184; 07. (1471) Moureu and Valeur, *27*, **9**: 468; 11. (1472) Moureu and Valeur, *34*, **152**: 527; 11. (1473) Moureu and Valeur, *6*, **27**: 245, 297; 12. (1474) Mourgues, *34*, **111**: 111; 90. (1475) Müller, *Thesis*, Zürich, 1915. *10*, **4**: 584; 21. (1476) Müntz, *34*, **94**: 453; 82. (1477) Müntz, *6*, **26**: 121; 82. (1478) Müntz and Aubin, *6*, **10**: 553; 77. (1479) Müther and Tollens, *25*, **37**: 306; 04.

(1480) Müther and Tollens, *25*, **37**: 311; 04. (1481) Murat, *49*, **4**: 297; 11. (1482) Musculus, *167*, **1869**: 745. (1483) Musculus, *34*, **88**: 612; 79. (1484) Musculus and Gruber, *34*, **86**: 1459; 78. (1485) Musculus and Gruber, *202*, **2**: 188; 78. (1486) Nasini and Gennari, *7*, **19**: 113; 96. (1487) Nasini and Pezzolato, *7*, **12**: 501; 93. (1488) Navassart, *55*, **12**: 97; 13. (1489) Neave, *4*, **101**: 513; 12.

(1490) Nef, *13*, **357**: 214; 07. (1491) Negovorov, *25*, **25**: 620; 92. (1492) Nelson, *1*, **33**: 1404; 11. (1493) Nelson, *1*, **36**: 2521; 14. (1494) Neuberg, *25*, **32**: 3384; 99. (1495) Neuberg, *25*, **33**: 2243; 00. (1496) Neuberg, *25*, **33**: 3315; 00. (1497) Neuberg, *25*, **35**: 1473; 02. (1498) Neuberg, *25*, **35**: 4009; 02. (1499) Neuberg, *25*, **39**: 1155; 06.

(1500) Neuberg and Asher, *205*, **1**: 380; 06. (1501) Neuberg and Asher, *205*, **5**: 451; 07. (1502) Neuberg and Brahn, *205*, **5**: 438; 07. (1503) Neuberg and Federer, *25*, **38**: 866; 05. (1504) Neuberg and Federer, *25*, **38**: 868; 05. (1505) Neuberg and Mayer, *202*, **44**: 472; 05. (1506) Neuberg and Neimann, *202*, **44**: 97; 05. (1507) Neuberg and Neimann, *202*, **44**: 114; 05. (1508) Neuberg and Rewald, *205*, **9**: 403; 08. (1509) Neuberg and Silbermann, *25*, **37**: 339; 04.

(1510) Neuberg and Silbermann, *202*, **44**: 134; 05. (1511) Neuberg and Wolff, *25*, **34**: 3840; 01. (1512) Neumann, *57*, **13**: 651; 92. (1513) Neville, *4*, **89**: 383; 06. (1514) Neville and Pickard, *4*, **85**: 685; 04. (1515) Nierenstein, *13*, **388**: 223; 12. (1515.5) Nossourtsch, *Thesis*, Zürich, 1912. (1516) Noyes and Burke, *1*, **34**: 174; 12. (1517) Noyes and Derick, *1*, **31**: 669; 09. (1518) Noyes and Derick, *1*, **32**: 1061; 10. (1519) Noyes, Gorsline and Potter, *1*, **34**: 62; 12.

(1520) Noyes and Homberger, *1*, **31**: 278; 09. (1521) Noyes and Homberger, *1*, **32**: 1665; 10. (1522) Noyes and Knight, *1*, **32**: 1669; 10. (1523) Noyes and Kyriakides, *1*, **32**: 1057; 10. (1524) Noyes and Littleton, *1*, **35**: 75; 13. (1525) Noyes and Nickell, *1*, **36**: 118; 14. (1526) Noyes and Phillips, *11*, **24**: 285; 00. (1527) Noyes and Potter, *1*, **34**: 1067; 12. (1528) Noyes and Potter, *1*, **37**: 189; 15. (1529) Noyes and Taveau, *11*, **35**: 379; 06.

(1530) Oddo, *36*, **27 I**: 149; 97. (1531) Odell, *1*, **33**: 755; 11. (1532) Ohlsson, *25*, **49**: 1341; 16. (1533) Oliveri-Mandalà and Comella, *36*, **53**: 619; 23. (1534) Oppé, *25*, **41**: 975; 08. (1535) Osborne, *131*, **9**: 69; 03. (1536) Ost, *25*, **24**: 1636; 91. (1537) O'Sullivan, *4*, **35**: 770; 79. (1538) O'Sullivan, *4*, **45**: 41; 84. (1539) Oudemans, *13*, **166**: 65; 73.

(1540) Oudemans, *13*, **182**: 33; 76. (1541) Oudemans, *13*, **197**: 48; 79. (1542) Oudemans, *13*, **209**: 38; 81. (1543) Oudemans, *70*, **1**: 18; 82. (1543.5) Oudemans, *70*, **1**: 173; 82. (1544) Oudemans, *70*, **4**: 166; 85. (1545) Oudemans, *70*, **8**: 147; 89. (1546) Oudemans, *70*, **9**: 171; 90. (1547) Paal, *25*, **49**: 1583; 16. (1548) Paal and Hörnstein, *25*, **39**: 1361; 06. (1549) Paal and Hörnstein, *25*, **39**: 2823; 06.

(1550) Paal and Kinscher, *25*, **44**: 3543; 11. (1551) Paal and Weidenkoff, *25*, **39**: 2827; 06. (1552) Paal and Zitelmann, *25*, **36**: 3337; 03. (1553) Palfray, *14*, **20**: 297; 23. (1554) Paneth, *57*, **32**: 257; 11. (1554.5) Paolini, *36*, **30 II**: 506; 00. (1555) Paolini, *22*, **20**: 769; 11. (1556) Paolini, *36*, **42 I**: 41; 12. (1556.5) Pöhl, *Russ. J. Pharm.*, **1880**: 129, 161, 193, 225. *27*, **34**: 341; 80. (1557) Pointet, *Thesis*, Paris, 1910. *10*, **4**: 589; 21. (1557.5) Parck, *Thesis*, Lund, 1921. *10*, **5**: 1042; 22. (1558) Parcus and Tollens, *13*, **257**: 160; 90. (1559) Pastanogoff, *Thesis*, Zürich, 1915.

(1560) Pasteur, *6*, **28**: 56; 50. (1561) Pasteur, *6*, **31**: 67; 51. (1562) Pasteur, *6*, **34**: 30; 52. (1563) Pasteur, *6*, **38**: 437; 53. (1564) Pasteur and Biot, *34*, **34**: 606; 52. (1565) Patterson, *4*, **79**: 167; 01. (1566) Patterson, *4*, **79**: 477; 01. (1567) Patterson, *4*, **81**: 1097; 02. (1568) Patterson, *4*, **81**: 1134; 02. (1569) Patterson, *4*, **85**: 1116; 04.

(1570) Patterson, *4*, **85**: 1152; 04. (1570.5) Patterson, *4*, **87**: 313; 05. (1571) Patterson, *4*, **93**: 1836; 08. (1572) Patterson, *4*, **103**: 145; 13. (1572.5) Patterson, *4*, **109**: 1139; 16. (1573) Patterson, *4*, **109**: 1176; 16. (1574) Patterson, *4*, **109**: 1204; 16. (1575) Patterson and Anderson, *4*, **101**: 1833; 12. (1576) Patterson and Davidson, *4*, **101**: 374; 12. (1577) Patterson and Forsyth, *4*, **103**: 2263; 13. (1578) Patterson and Frew, *4*, **89**: 332; 06. (1579) Patterson, Henderson and Fairlie, *4*, **91**: 1838; 07. (1579.5) Patterson and Kaye, *4*, **89**: 1884; 06.

(1580) Patterson and Kaye, *4*, **91**: 705; 07. (1581) Patterson and McArthur, *4*, **107**: 814; 15. (1582) Patterson and McDonald, *4*, **93**: 936; 08. (1583) Patterson and McDonald, *4*, **95**: 321; 09. (1584) Patterson and McMillan, *4*, **91**: 504; 07. (1585) Patterson and Montgomeris, *4*, **95**: 1128; 09. (1586) Patterson and Patterson, *4*, **107**: 142; 15. (1587) Patterson and Pollock, *4*, **105**: 2322; 14. (1588) Patterson and Stevenson, *4*, **97**: 2110; 10. (1589) Patterson and Stevenson, *4*, **101**: 241; 12. (1589.5) Patterson and Taylor, *4*, **87**: 33; 05.

(1590) Patterson and Thomson, *25*, **40**: 1243; 07. (1591) Patterson and Thomson, *4*, **93**: 355; 08. (1592) Peacock, *4*, **103**: 669; 13. (1593) Peacock, *4*, **105**: 2782; 14. (1594) Peacock, *4*, **107**: 1547; 15. (1595) Peemann, *4*, **105**: 1679; 14. (1596) Peligot, *34*, **90**: 1141; 80. (1597) Pellini, *36*, **45**: 380; 15. (1597.5) Pelouze, *6*, **35**: 222; 52. (1598) Perkin, *4*, **81**: 177; 02. (1599) Perkin, *4*, **81**: 292; 02.

(1600) Perkin, *4*, **97**: 2129; 10. (1600.5) Perkin and Pope, *4*, **99**: 1510; 11. (1601) Perkin, Pope and Wallach, *4*, **95**: 1789; 09. (1601.5) Perkin, Pope and Wallach, *13*, **371**: 180; 09. (1601.8) Perkin and Robinson, *182*, **26**: 131; 10. (1602) Perkin and Robinson, *4*, **99**: 775; 11. (1603) Perkin and Robinson, *4*, **119**: 1392; 21. (1604) Perkin and Scarborough, *4*, **119**: 1400; 21. (1605) Perkin and Wallach, *4*, **97**: 1427; 10. (1606) Perkin and Yates, *4*, **79**: 1573; 01. (1607) Perucca, *23*, **49**: 1127; 14. (1607.5) Pesci, *36*, **16**: 225; 86. (1608) Pesci, *36*, **18**: 219; 88. (1609) Pesci, *36*, **21 I**: 1; 91.

(1610) Peters, *4*, **81**: 1350; 02. (1611) Petersen, *Diss.*, Breslau, 1888. (1612) Pfannl, *57*, **32**: 241; 11. (1613) Pfannl and Wölfel, *57*, **34**: 963; 13. (1614) Phillipe, *34*, **147**: 1481; 08. (1615) Phillipe, *34*, **152**: 1774; 11. (1616) Phillipe, *6*, **26**: 289; 12. (1617) Phillips, *4*, **123**: 22; 23. (1618) Pickard, Hunter, Lewcock and de Pennington, *4*, **117**: 1248; 20. (1619) Pickard and Kenyon, *4*, **99**: 45; 11.

(1620) Pickard and Kenyon, *4*, **101**: 620; 12. (1621) Pickard and Kenyon, *4*, **101**: 1427; 12. (1622) Pickard and Kenyon, *4*, **103**: 1923; 13. (1623) Pickard and Kenyon, *4*, **105**: 830; 14. (1624) Pickard and Kenyon, *4*, **105**: 1115; 14. (1625) Pickard, Kenyon and Hunter, *4*, **123**: 1; 23. (1626) Pickard, Lewcock and Yates, *182*, **29**: 127; 13. (1627) Pickard and Littlebury, *4*, **89**: 467; 06. (1628) Pickard and Littlebury, *4*, **91**: 300; 07. (1629) Pickard and Littlebury, *4*, **91**: 1973; 07.

(1630) Pickard and Littlebury, *4*, **101**: 109; 12. (1631) Pickard, Littlebury and Neville, *4*, **89**: 93; 06. (1632) Pickard and Neville, *4*, **87**: 1763; 05. (1633) Pickard and Yates, *4*, **89**: 1101; 06. (1634) Pickard and Yates, *4*, **89**: 1484; 06. (1635) Pickard and Yates, *4*, **93**: 1928; 08. (1636) Pickard and Yates, *4*, **95**: 1011; 09. (1637) Pickles and Whitfield, *182*, **27**: 54; 11. (1638) Pictet, *149*, **7**: 82; 82. (1639) Pictet, *34*, **137**: 860; 03.

(1640) Pictet and Bacovesen, *25*, **38**: 2787; 05. (1641) Pictet and Court, *27*, **1**: 1001; 07. (1642) Pictet and Court, *25*, **40**: 3771; 07. (1643) Pictet and Jenny, *25*, **40**: 1172; 07. (1644) Pictet and Mattisson, *25*, **38**: 2782; 05. (1645) Pictet and Rotschy, *25*, **37**: 1225; 04. (1646) Piettre, *34*, **147**: 810; 08. (1647) Pinner and Schwartz, *25*, **35**: 192; 02. (1648) Piutti, *25*, **19**: 1691; 86. (1649) Piutti, *172(7th)*, **4a**: 293; 11.

(1650) Piutti and Magli, *36*, **36 II**: 738; 06. (1651) Planta-Reichenau and Schulze, *25*, **23**: 1692; 90. (1652) Planta-Reichenau and Schulze, *25*, **24**: 2705; 91. (1653) Plimpton, *4*, **39**: 331; 81. (1654) Plimpton, *34*, **92**: 531, 882; 81. (1655) Plugge and van de Moer, *293*, **229**: 48; 91. (1656) Plzák, *25*, **36**: 1761; 03. (1658) Polak, *Thesis*, Amsterdam, 1914. (1659) Polonovski, *27*, **19**: 46; 16.

(1660) Pope, *4*, **75**: 1105; 99. (1661) Pope and Clarke, *4*, **85**: 1330; 04. (1662) Pope and Gibson, *4*, **97**: 2207; 10. (1662.5) Pope and Gibson, *4*, **101**: 735; 12. (1663) Pope and Gibson, *4*, **101**: 740; 12. (1664) Pope and Gibson, *4*, **101**: 939; 12. (1665) Pope and Gibson, *4*, **101**: 1702; 12. (1666) Pope and Harvey, *4*, **75**: 1110; 99. (1667) Pope and Harvey, *4*, **79**: 74; 01. (1668) Pope and Harvey, *4*, **79**: 828; 01. (1669) Pope and Neville, *4*, **81**: 1552; 02.

(1670) Pope and Peachey, *4*, **73**: 893; 98. (1671) Pope and Peachey, *4*, **75**: 1111; 99. (1672) Pope and Peachey, *4*, **75**: 1066; 99. (1673) Pope and Peachey, *4*, **75**: 1127; 99. (1674) Pope and Peachey, *4*, **77**: 1072; 00. (1675) Pope and Read, *4*, **95**: 171; 09. (1676) Pope and Read, *4*, **97**: 987; 10. (1677) Pope and Read, *4*, **97**: 2199; 10. (1678) Pope and Read, *4*, **99**: 2071; 11. (1679) Pope and Read, *4*, **101**: 758; 12.

(1680) Pope and Read, *4*, **101**: 519; 12. (1681) Pope and Read, *4*, **103**: 444; 13. (1682) Pope and Read, *4*, **103**: 1515; 13. (1683) Pope and Read, *4*, **105**: 219; 14. (1684) Pope and Read, *4*, **105**: 800; 14. (1685) Pope and Read, *4*, **105**: 811; 14. (1686) Pope and Read, *201*, **17**: 475; 14. (1687) Pope and Read, *83*, **10**: 118; 14. (1688) Pope and Rich, *4*, **75**: 1093; 99. (1689) Pope and Taylor, *4*, **103**: 1763; 13.

(1690) Pope and Winmill, *4*, **101**: 2309; 12. (1691) Popovici, *202*, **13**: 445; 89. (1692) Porter and Noyes, *1*, **45**: 2366; 23. (1693) Power and Barrowcliff, *4*, **87**: 884; 05. (1694) Power and Browning, *4*, **101**: 2411; 12. (1695) Power and Callan, *4*, **99**: 1993; 11. (1696) Power and Gornall, *4*, **85**: 851; 04. (1697) Power and Moore, *4*, **97**: 99; 10. (1698) Power and Moore, *4*, **97**: 1099; 10. (1699) Power and Moore, *4*, **99**: 937; 11.

(1700) Power and Rogerson, *184*, **80**: 251; 08. (1701) Power and Rogerson, *4*, **97**: 1944; 10. (1702) Power and Rogerson, *1*, **32**: 80; 10. (1703) Power and Rogerson, *347*, **84**: 326; 10. (1704) Power and Rogerson, *172(7th)*, **4a**: 324; 10. (1705) Power and Rogerson, *4*, **101**: 1; 12. (1706) Power and Rogerson, *4*, **101**: 398; 12. (1707) Power and Salway, *1*, **30**: 251; 08. (1708) Power and Salway, *4*, **97**: 231; 10. (1709) Power and Salway, *4*, **99**: 490; 11.

(1710) Power and Salway, *4*, **103**: 191; 13. (1711) Power and Salway, *4*, **105**: 201; 14. (1712) Power and Salway, *4*, **105**: 1062; 14. (1713) Power and Tutin, *4*, **85**: 624; 04. (1714) Power and Tutin, *293*, **245**: 337; 07. (1715) Power, Tutin and Rogerson, *4*, **103**: 1267; 13. (1716) Pribram, *75*, **97 II**: 460; 88. (1717) Pribram, *25*, **22**: 6; 89. (1718) Prilzhaev, *53*, **44**: 613; 12. (1719) Pringsheim and Eissler, *25*, **46**: 2959; 13.

(1720) Pringsheim and Goldstein, *25*, **56**: 1520; 23. (1721) Pringsheim and Langhans, *25*, **45**: 2533; 12. (1722) Pryde, *4*, **123**: 1808; 23. (1723) Pschorr, *25*, **45**: 2212; 12. (1724) Pschorr and Dickhäuser, *25*, **44**: 2633; 11. (1725) Pschorr and Dickhäuser, *25*, **45**: 1567; 12. (1726) Pschorr, Jaeckel and Fecht, *25*, **35**: 4377; 02. (1727) Pum, *57*, **13**: 676; 92. (1728) Purdie, *4*, **63**: 1143; 93. (1729) Purdie and Barbour, *4*, **79**: 971; 01.

(1730) Purdie and Bolam, *4*, **67**: 944; 95. (1731) Purdie and Irvine, *4*, **75**: 483; 99. (1732) Purdie and Irvine, *4*, **79**: 957; 01. (1733) Purdie and Irvine, *4*, **83**: 1021; 03. (1734) Purdie and Irvine, *4*, **85**: 1049; 04. (1735) Purdie and Irvine, *4*, **87**: 1022; 05. (1736) Purdie and Lander, *4*, **73**: 287; 98. (1737) Purdie and Lander, *4*, **73**: 862; 98. (1738) Purdie and Marshall, *4*, **63**: 217; 93. (1739) Purdie and Neave, *4*, **97**: 1517; 10.

(1740) Purdie and Pitkeathly, *4*, **75**: 153; 99. (1741) Purdie and Rose, *4*, **89**: 1204; 06. (1742) Purdie and Walker, *4*, **61**: 754; 92. (1743) Purdie and Walker, *4*, **63**: 229; 93. (1744) Purdie and Williamson, *4*, **67**: 957; 95. (1745) Purdie and Williamson, *4*, **69**: 818; 96. (1746) Purdie and Young, *4*, **89**: 1194; 06. (1747) Purdie and Young, *4*, **97**: 1524; 10. (1748) Purvis, *4*, **107**: 643; 15. (1749) Pyman, *4*, **99**: 1386; 11.

(1750) Pyman, *4*, **101**: 2260; 12. (1751) Pyman, *4*, **103**: 817; 13. (1752) Pyman, *4*, **111**: 419; 17. (1753) Pyman, *4*, **113**: 222; 18. (1754) Rabe, *13*, **350**: 180; 06. (1755) Rabe, *13*, **364**: 330; 09. (1756) Rabe, *13*, **373**: 85; 10. (1757) Rabe and Braasch, *13*, **365**: 366; 09. (1758) Rabe and Weilinger, *25*, **36**: 227; 03. (1759) Rakuzin, *53*, **47**: 141; 15.

(1760) Rakuzin, *53*, **48**: 265; 16. (1761) Rakuzin and Brando, *53*, **47**: 1057; 15. (1762) Rakuzin and Brando, *53*, **48**: 97; 16. (1763) Rakuzin and Brando, *53*, **48**: 269; 16. (1764) Ramberg, *25*, **33**: 3354; 00. (1765) Ramberg, *13*, **349**: 324; 06. (1766) Ramsay, *25*, **42**: 1137; 09. (1767) Raper, *4*, **123**: 2557; 23. (1768) Rauwerda, *293*, **238**: 477; 00. (1769) Rayman and Kruis, *27*, **48**: 632; 87.

(1770) Read and Smith, *4*, **123**: 2267; 23. (1771) Reinke and Rodewald, *13*, **207**: 229; 81. (1772) Reiss, *25*, **22**: 609; 89. (1773) Reitter, *202*, **36**: 129; 01. (1774) Remfry, *4*, **103**: 1076; 13. (1775) Reychler, *27*, **27**: 979; 02. (1776) Reychler, *27*, **29**: 134; 03. (1777) Riban, *6*, **6**: *5*; 75. (1778) Riban, *6*, **6**: 215; 75. (1779) Riban, *6*, **6**: 353; 75.

(1780) Riesser, *202*, **49**: 210; 06. (1781) Rieth, *Diss.*, Gottingen, 1861. (1782) Riiber, *25*, **48**: 823; 15. (1783) Rimbach, *7*, **9**: 698; 92. (1783.5) Rimbach, *25*, **32**: 2385; 99. (1784) Rimbach and Volk, *7*, **77**: 385; 11. (1784.5) Rimbach and Weber, *7*, **51**: 473; 05. (1785) Rischbiet and Tollens, *13*, **232**: 172; 86. (1786) Rogers, *4*, **63**: 1130; 93. (1787) Rogerson, *4*, **97**: 1004; 10. (1788) Rogier, *Thesis*, Paris, 1912. *10*, **4**: 1092; 21. (1789) van Romburgh, *70*, **5**: 219; 86.

(1790) van Romburgh, *64P*, **13**: 1177; 11. (1791) van Romburg and Barger, *4*, **99**: 2068; 11. (1792) van Romburgh and Cohen, *64P*, **8**: 544; 05. (1793) van Romburgh and Wensink, *64P*, **16**: 1088; 14. (1794) Roques, *34*, **120**: 1170; 95. (1795) Rosenheim and Aron, *93*, **39**: 170; 04. (1796) Rosenheim and Itzig, *25*, **33**: 707; 00. (1797) Rosenheim and Schidrowitz, *4*, **73**: 878; 98. (1798) Rosenthaler and Ström, *293*, **250**: 290; 12. (1798.5) Rosenheim and Tebb, *289*, **37**: i; 08. (1799) Roser, *13*, **247**: 167; 88.

(1800) Ross and Payne, *1*, **45**: 2363; 23. (1801) Roster, *36*, **9**: 364; 79. (1802) Roux, *34*, **135**: 691; 02. (1803) Roux, *34*, **136**: 1079; 03. (1804) Roux, *6*, **1**: 160; 04. (1804.5) Roux, *34*, **138**: 503; 04. (1805) Ruff, *25*, **32**: 3672; 00. (1806) Ruff, *25*, **34**: 1362; 01. (1807) Ruff, *25*, **35**: 2360; 02. (1808) Ruff and Ollendorff, *25*, **33**: 1798; 00. (1809) Ruhemann and Dufton, *4*, **59**: 750; 91.

(1810) Rupe, *13*, **327**: 157; 03. (1810.5) Rupe, *13*, **373**: 121; 10. (1811) Rupe, *13*, **395**: 87; 13. (1812) Rupe, *13*, **395**: 136; 13. (1813) Rupe, *13*, **398**: 372; 13. (1814) Rupe, *13*, **402**: 149; 13. (1815) Rupe, *83*, **10**: 46; 14. (1816) Rupe, *13*, **409**: 327; 15. (1817) Rupe, *13*, **428**: 188; 22. (1818) Rupe and Akermann, *13*, **420**: 1; 20. (1819) Rupe, Akermann and Takagi, *37*, **1**: 452; 18.

(1820) Rupe and Burckhardt, *25*, **49**: 2547; 16. (1821) Rupe and Buselt, *13*, **369**: 311; 09. (1822) Rupe and Courvoisier, *37*, **6**: 1049; 23. (1823) Rupe and Dorschky, *25*, **39**: 2112; 06. (1824) Rupe and Ebert, *25*, **41**: 2067; 08. (1825) Rupe and Emmerich, *25*, **41**: 1393; 08. (1826) Rupe and Emmerich, *25*, **41**: 1750; 08. (1826.5) Rupe and Glenz, *13*, **436**: 184; 24. (1827) Rupe and Frisell, *25*, **38**: 104; 05. (1828) Rupe and Glenz, *13*, **436**: 184; 24. (1829) Rupe and Iselin, *25*, **49**: 25; 16.

(1830) Rupe and Jäger, *13*, **402**: 149; 14. (1831) Rupe and Jäggi, *37*, **3**: 654; 20. (1832) Rupe and Jäggi, *13*, **428**: 164; 22. (1833) Rupe and Kägi, *13*, **420**: 33; 20. (1834) Rupe and Kerhovins, *25*, **45**: 1398; 12. (1835) Rupe and Lauger, *37*, **3**: 272; 20. (1836) Rupe and Lotz, *25*, **36**: 2796; 03. (1837) Rupe and Lotz, *25*, **39**: 4076; 06. (1838) Rupe and Münster, *13*, **373**: 121; 10. (1839) Rupe, Pfeiffer and Splittgerber, *25*, **40**: 2813; 07.

(1840) Rupe and Ronus, *25*, **33**: 3541; 00. (1841) Rupe and Schlochoff, *25*, **38**: 1719; 05. (1842) Rupe and Schmid, *37*, **5**: 437; 22. (1842.5) Rupe, Seiberth and Kussmaul, *37*, **3**: 50; 20. (1843) Rupe, Seiberth and Kussmaul, *37*, **3**: 71; 20. (1844) Rupe and Silberstrom, *13*, **414**: 99; 18. (1845) Rupe and Splittgerber, *25*, **40**: 4311; 07. (1846) Rupe and Tomi, *25*, **47**: 3064; 14. (1847) Rupe and Tomi, *25*, **49**: 2563; 16. (1848) Rupe, Werder and Togaki, *37*, **1**: 309; 18. (1849) Rupe and Wild, *13*, **414**: 111; 17.

(1850) Ryan and Ebrill, *Sci. Proc. Roy. Irish Acad.*, **24B**: 379; 03. (1851) Ryan, and Fitzgerald, *Ibid*, **30B**: 106; 13. (1852) Sabatier and Murat, *34*, **156**: 184; 13. (1853) Saillard, Wehrung and Ruby, *Mon. sci. Quesneville*, **5**: 4, 236. *10*, **4**: 584; 21. (1854) Salomon, *52*, **28**: 82; 83. (1855) Salway, *4*, **99**: 2148; 11. (1856) Salway, *4*, **101**: 978; 12. (1857) Salway, *4*, **103**: 1022; 13. (1858) Sandelin, *13*, **396**: 285; 12. (1858.5) Schardinger, *57*, **11**: 551; 90. (1859) Scheermesser, *202*, **41**: 68; 04.

(1860) Scheibler, *25*, **1**: 108; 68. (1861) Scheibler, *25*, **13**: 2212; 80. (1862) Scheibler, *25*, **17**: 1725; 84. (1862.5) Scheibler, *25*, **17**: 1729; 84. (1863) Scheibler, *25*, **18**: 1779; 85. (1864) Scheibler, *25*, **45**: 2272; 12. (1865) Scheibler and Mittelmeier, *25*, **23**: 1438; 90. (1866) Scheibler and Mittelmeier, *25*, **26**: 1331; 93. (1867) Scheibler and Wheeler, *25*, **44**: 2684; 11. (1868) Scheuer, *7*, **72**: 513; 10. (1869) Schiff, *13*, **166**: 94; 73.

(1870) Schiff, *136*, **19**: 1680; 95. **20**: 865; 96. (1871) Schiller, *25*, **42**: 2017; 09. (1871.5) Schimmel & Co., *185*, **1902**, I: 1058. (1872) Schimmel & Co., *Semi-annual Rept.*, Oct., **1910**: 123. (1873) Schimmel & Co., *Ibid*, Oct., **1912**: F45. (1874) Schimmel & Co., *Ibid*, Oct., **1912**: F85. (1875) Schlubach and Moog, *25*, **56**: 1957; 23. (1876) Schlundt, *50*, **7**: 194; 03. (1877) Schmitt and Cobenzl, *25*, **17**: 1000; 84. (1878) Schneider, *13*, **207**: 257; 81. (1879) Schneider, Clibben, Hüllweck and Steibelt, *25*, **47**: 1258; 14.

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The following index contains the names of the simpler chemical compounds and the "common" names of the more complicated compounds, in so far as such common names exist. Complicated compounds which are named only in terms of their chemical structure should be located from the system of arrangement as explained in the Introduction. In general, only the parent compound is indexed, since derivatives are almost always to be found in the same section.

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COMMERCIAL EXPLOSIVES

WILLIAM RINTOUL AND GODFREY ROTTER

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ABBREVIATIONS

DNT	Dinitrotoluene.
MNN	Mononitronaphthalene.
N/B	Aromatic nitro body.
N/G	Nitroglycerin.
TNN	Trinitronaphthalene.
TNT	Trinitrotoluene.

INTRODUCTION

Pure compounds are not used to any great extent in civil applications of explosives. Ordinary commercial blasting and propulsive explosives have usually an empirical composition, with fairly wide tolerances for the proportions of the several ingredients, and very often one or more of these constituents is a substance of indefinite chemical composition. Furthermore the treatment during the process of manufacture, for example the fineness of the ingredients used, the time of mixing, and the physical condition of the product, have considerable influence on the properties of the finished explosive.

Data are tabulated relating to the principal explosive properties of the chief pure explosive substances, but for compounded explosives only typical or limiting compositions and properties are given.

TYPES OF TESTS

The principal tests used for explosives are described briefly below:

1. Calorimetric tests to determine the *heat of explosion* and the *volume and composition of the explosion gases*. For descriptions of the method of carrying out the experiments, *see* Vol. II, p. 440–444 of (25) and (39, 40).

The explosion temperature has not been determined directly, but can in principle be calculated from the pressure developed when the substance is exploded in a closed vessel. Various types of apparatus for determining the maximum pressures developed, or for recording variations in pressure, are described in (25). Explosion temperatures may also be calculated from the heat of explosion if the nature, amounts and specific heats of the explosion products are known.

2. *Trauzl Lead-block Test.*—This test is used for blasting explosives[1] as a ready means of estimating the relative powers of explosives of the same class fired under slight confinement. At the Berlin meeting (1903) of the International Congress of Applied Chemistry, standard conditions for carrying out this test were prescribed (2). Kast (19) gives a table of corrections for temperature.

3. The *fall-hammer test* is used to measure approximately the sensitiveness to shock of an explosive. The classification of explosives for transport on the German railways is based, in part, on the results of this test. The method of carrying it out is described in (14, 15), and by Marshall (25), Vol. II, p. 423.

4. The *deflagration test* for the determination of the explosion temperature serves to measure the sensitiveness of the explosive to active decomposition by the action of heat.

5. A large number of so-called "stability tests" have been developed in order to obtain some idea of the chemical stability of explosives during storage. Among these may be mentioned the *Abel*, *Bergmann-Junk*, *Will* and *Sy* tests.

6. The *bulk density* of an explosive is an important factor in its behavior and this property can be varied within fairly wide limits by modifications in the method of manufacture.

7. The *detonation velocity* of an explosive is one of the most important factors in its brisance, and, therefore, in its practical applications. The methods used for measuring it are described in the textbooks; *see*, for example (25) Vol. II, p. 476. A discussion by Kast of the sources of error when the Siemens spark chronograph is used is largely applicable to any chronographic method (17).

The value found depends on the diameter of the train of explosive used (up to a certain limiting value, varying with the nature of the explosive); on the degree of confinement to which it is subjected; and on the method of initiation.

The detonation velocity increases in general with the density. In the case of certain explosives this increase continues up to a certain critical density, after which it falls rapidly. In the case of some of the less porous nitro bodies it has not yet been proved that the detonation value does decrease in this way after a certain limit, although there are indications that this is probably so.

Nitroglycerin gelatinous explosives have two distinct detonation velocities. That which is attained depends on various factors, but especially on the nature of the initiation and on the degree of confinement.

The following tests are of special importance in connection with coal mine explosives:

8. *Tests in an experimental gallery* to determine the maximum charge which can be fired without igniting an air-gas mixture containing specified proportions of an inflammable gas or coal dust or both. Natural firedamp, artificially prepared methane and illuminating gas have been used as the inflammable gas. A brief historical sketch of the various gallery tests is given in (13). A table appended to that pamphlet gives data regarding the principal testing galleries. On the basis of these tests limiting charges of explosive are fixed for use in mines.

9. *Ballistic pendulum tests* are used in Great Britain and the United States to furnish a comparative estimate of the strength of the explosive, the results being published as a guide to the purchaser in the selection of an explosive suitable for his requirements.

In the United States the detonation velocity of permissible coal mine explosives is also published, but this is not done for the British "permitted" explosives.

10. For propulsive explosives, tests are carried out in appropriate weapons to measure the *pressure developed in the barrel of the gun*, usually by means of crusher gages, and to determine the *velocity of the projectile*, and, for shotgun cartridges, the *shot "pattern."*

Velocities are measured over a certain distance from the muzzle of the gun by the use of a suitable target in conjunction with a chronograph. The result may be given as the average velocity over this distance or as the "remaining velocity" at half the distance, or a calculated value of the "muzzle velocity" may be reported. V_x is used to denote the remaining velocity at x meters (or other unit) found by means of a target placed at $2x$ meters from the gun.

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[1] In the U. S. A. the ballistic mortar test described under 9, below, is largely used by manufacturers of explosives.

11. For initiating explosives, in addition to the heat of explosion, the explosion point and the result of the fall-hammer test, there may also be given the result of a test similar to the Trauzl lead-block test but using a smaller lead block; of the *"lead plate" test* (which, however, does not furnish definite numerical results); of tests on the *limiting charge* required to initiate the detonation of a definite quantity of some explosive (usually a nitro body); of the *Esop* and *Wöhler tests* in which an explosive is phlegmatized in some manner until it is just no longer "initiated" by the initiator under test; or of the *"sand" test* developed by the U. S. A. Bureau of Mines, in which a detonating charge is exploded in the center of graded sand, and the degree of pulverization of the sand produced by the explosion is measured.

SIMPLE EXPLOSIVES (PURE SUBSTANCES)

Heat of Explosion

Explosion in calorimetric bomb. The heat of explosion may also be calculated from thermochemical data (*q.v.*, Vol. V, p. 162, 169), the results agreeing well with the experimental. Alternative methods of decomposition may be possible and the heat of explosion may thus vary, for example, with the loading density or the nature of the initiation.

Abbreviations

(g), Gaseous; (l) liquid; d, density; L.d., loading density.

Conversion Factors

1 g-cal$_{15}$/g = 4.185 joule/g = 1.800 BTU$_{60}$/lb.

Substance	Heat of explosion, g-cal$_{15}$ per gram	Notes	Lit.
Ammonium nitrate	630	$H_2O(l)$	(32, 37)
$2NH_4NO_3 = 2N_2 + 4H_2O + O_2$ (requires strong detonator)	350	$H_2O(g)$	(1, 6)
$2NH_4NO_3 = N_2 + 4H_2O + 2NO$	115	$H_2O(g)$	(1, 6)
$NH_4NO_3 = N_2O + 2H_2O$	127.5	$H_2O(g)$	(1, 6)
Cyanuric triazide	1140		(21)
Guncotton, 13%N	982	$H_2O(g)$; L.d., 1.3	(30)
	1100	$H_2O(l)$	(32, 37)
12%N	730	$H_2O(l)$	(32, 37)
Lead azide	364		(26)
	360		(6)
	260	Pb(g)	(21)
Lead trinitroresorcinate	205(?)	Pb(g)	(21)
Mannitol hexanitrate	1454, 1520		(20, 37)
Mercury azide	266		(26)
Mercury fulminate	410		(37, 38)
	431	Hg(l)	(21)
	368	Hg(g)	(21)
m-Dinitrobenzene	820	$H_2O(g)$; L.d., 1.3	(30)
Nitroglycerin	1478	$H_2O(g)$;	(30)
	1550 to 1590		(5, 29, 37)
Picric acid	717	$H_2O(g)$	(3)
	840	$H_2O(l)$	(32)
	914	$H_2O(g)$; L.d., 1.3	(30)
	809	Mean for various L.ds.	(12)
Silver fulminate	470		(26)
Tetranitromethylaniline (tetryl)	1090	$H_2O(g)$; L.d., 1.3	(30); *cf.* (10)
Trinitrobenzene	940	$H_2O(g)$; L.d., 1.3	(30)
Trinitrotoluene	880	$H_2O(l)$	(32)
	924	$H_2O(g)$; L.d., 1.3	(30)
	881 to 892	L.d., 0.2; d, 1.45	(12)

Trauzl Lead-Block Test

Explosive	Expansion, cm^3	Lit.
Ammonium nitrate	142*	(49)
	103†	(49)
	165 198	(19, 27)
Ammonium chlorate	240	(19, 28)
Ammonium perchlorate	140	(19)
	193	(27)
Dinitrobenzene	250	(19)
Dinitroglycerin (gelatinized)	330	(5)
Guncotton	360‡	(3)
	375	(19)
Dry, compressed, 12.77%N	317‡	(47)
Dry, compressed, 13.18%N	352‡	(47)
	290	(10)
With 13%N	420§	(6)
Wet	280	(19)
With 20% water	280	(32)
Hexanitrodiphenylamine	320	(19)
	352	(33)
Hexanitrophenyl sulfide	355	(33)
Hydrazine nitrate (basic)	362*	(50)
Nitroglycerin	515	(19)
	600	(32)
	600§	(6)
	550‖	(28)
	590‖	(28)
Nitromannite	650§	(6)
Nitropentaerythritol	460	(32)
Nitrostarch	305	(33)
Picric acid	302¶	(44)
	292*††	(47)
	330	(33)
	297	(10)
	287	(45)
Acid as powder	301*	(45)
Acid cast	264*	(45)
Acid compressed	292*	(45)
	305	(32)
Tetranitroaniline	400‡	(50)
	415	(33)
	430	(10)
Tetranitroanisole	390	(32)
Tetryl (Powder)	357**	(46)
(Cast)	322‡**	(46)

Trauzl Lead-Block Test.—(*Continued*)

Explosive	Expansion, cm³	Lit.
Tetryl.—(*Cont'd*)		
(Pressed)	322‡**††	(46)
	340	(19)
	375	(33)
	375	(10)
	369‡	(50)
	374‡	(49)
	348	(48)
Trinitroanisole	290	(19)
	322	(33)
Trinitrobenzene	330	(19)
	364	(33)
Trinitrochlorobenzene	295	(19)
	322	(33)
Trinitrocresol	275	(19)
	301	(33)
Trinitrotoluene	300‡	(3)
	285	(19)
	274	(33)
	254	(10)
	238	(48)
	260§	(6)
Mean of 25 results	249	(7.5)
Commercial (Powder)	289* **	(46)
(Cast)	102* **	(46)
(Pressed)	54**††	(46)
(Powder)	280‡‡	(46)
(Cast)	208‡‡	(46)
(Pressed)	255††‡‡	(46)

* Volume of borehole, 63 cm³, deducted.

† With picric acid as primer, 297 cm³ deducted for primer, 63 cm³ for original volume of borehole.

‡ Volume of borehole deducted.

§ After deducting 61 cm³ for borehole and 17 cm³ for No. 8 detonator.

‖ Liquid N/G with sand tamping.

¶ Acid finely crystalline.

** No. 8 detonator.

†† Pressed at 1246 kg per cm.²

‡‡ No. 8 tetryl detonator.

Lead-Block Test (Initiating Explosives) (21)

In testing initiating explosives a smaller lead block is used, 80 mm in diameter and 80 (or 100) mm high with a charge of 2 g of the substance

Explosive	Expansion, cm³	*d**
Cyanuric triazide	131.3	1.2
Lead azide	26	2
Lead trinitroresorcinate	29	1.8
Mercury fulminate	33	1.7

* *d* = density of explosive, g/cm³.

Fall-Hammer Test

Results for 2 kg hammer

Explosive	Fall in cm	Lit.
Ammonium picrate	80	(36)
Copper picrate	7	(36)
Dinitrobenzene	>60	(16)
	150	(16)

Fall-Hammer Test.—(*Continued*)

Explosive	Fall in cm	Lit.
Dinitroglycerin	7	(36)
Moist	30	(42)
Dinitrophenol	150	(36)
Guncotton compressed, 15% H_2O	85	(36)
20% H_2O	>180	(36)
Dry	17 to 18	(41)
+20% H_2O	>183*	(41)
+35% H_2O	>183	(41)
Hexanitrodiphenylamine	40	(36)
Iron picrate	7	(36)
Lead picrate	5	(36)
Nitrocotton (collodion cotton), compressed, 15% H_2O	100	(36)
20% H_2O	>180	(36)
Dry	36	(41)
+20% H_2O	>183*	(41)
+35% H_2O	>183	(41)
Nitroglycerin, dry	4	(36)
Moist	4	(42)
Liquid	10†	(43)
Frozen	38 to 40†	(43)
Picric acid (finely crystalline)	35 to 95	‡
Silver picrate	5	(36)
Sodium picrate	80	(36)
Tetryl	40 to 65	(36)
	30	(32)
Trinitroanisole	>60	(16)
Trinitrobenzene	40 to 50	(36)
Trinitrocresol	30	(36)
Trinitrodimethylaniline	95	(36)
Trinitronaphthalene	175	(36)
Trinitrotoluene	57–90 and up to 180	‡
Zinc picrate	60	(36)

* Partly caked residue.

† For 1 kg hammer.

‡ Various sources.

Explosive	Weight of explosive, g	Weight of hammer, g	Fall in cm	Lit.
Azides, Ba	0.02	599	14	(26)
Cd	0.02	964	27.5	(26)
Cu	0.01	599	9.5	(26)
	0.02	599	10.5	(26)
	0.03	599	13.0	(26)
	0.05	599	24.0	(26)
Pb	0.01	599	17	(26)
	0.02	599	17	(26)
	0.05	599	14.5	(26)
Hg	0.01	599	17	(26)
	0.02	599	16.5	(26)
	0.05	599	14	(26)
Ag	0.05	964	18	(26)
Na	0.05	820	>30	(22)
Fulminates, Hg	0.05	500	7.5	(22)
		2000	2	(9)
Na	0.05	620	30	(22)

Limiting Charges Necessary for Various Initiating Explosives

Initiating explosive A	Explosive B against which tested	Amount of explosive B, g	Limiting charge of explosive A required for detonation of B, g	Lit.
Lead azide*.....	Tetryl	0.5	0.025	(26)
	Picric acid	0.5	0.025	(26)
	TNT	0.5	0.09	(26)
	Trinitroanisole	0.5	0.28	(26)
Mercury fulminate†........	Picric acid	1	0.25	(38)
	TNT	1	0.30	(38)
	TNT	0.5	0.25	(22)
	Tetryl	0.4	0.35‡	(34)
	Tetranitroaniline	0.4	0.45	(34)
	Picric acid	0.4	0.40§	(34)
	TNT	0.4	0.26‖	(34)
	Picric acid	0.5	0.30	(26)
	Tetryl	0.5	0.29	(26)
	TNT	0.5	0.36	(26)
	Trinitroanisole	0.5	0.37	(26)
	Trinitroxylene	0.5	0.43	(26)
	TNT		0.26¶	(35)
			0.30**	(35)
	Tetryl		0.24¶	(35)
			0.25**	(35)
	Guncotton	0.5	0.20††	(38)
	Picric acid	1.0	0.25 to 30††	(38)
	Trinitroresorcinol	1.0	0.20††	(38)
	Trinitrocresol	1.0	0.30††	(38)
	Trinitrobenzoic acid	1.0	0.25††	(38)
	Trinitrobenzene	1.0	0.25††	(38)
	TNT	1.0	0.30††	(38)
	Trinitroxylene	1.0	0.40††	(38)
Mercury fulminate +0.01g lead azide..	TNT	0.5	0.02	(22)
Mercury fulminate +20% lead azide..	TNT		0.18¶	(35)
			0.06¶	(35)
	Tetryl		0.06**	(35)
Mercury fulminate-potassium chlorate mixture, 90:10........	Tetryl	0.4	0.3000	(34)
	Tetranitroaniline	0.4	0.3125	(34)
	Picric acid	0.4	0.3750‡‡	(34)
	TNT	0.4	0.2500‖	(34)
80:20.........	Tetryl	0.4	0.2750	(34)
	Tetranitroaniline	0.4	0.3125	(34)
	Picric acid	0.4	0.3750§§	(34)
	TNT	0.4	0.2400‖	(34)
Silver azide.....	Guncotton	0	0.05††	(38)
	Picric acid	1	0.025††	(38)
	Trinitroresorcinol	1	0.08††	(38)
	Trinitrocresol	1	0.05††	(38)
	Trinitrobenzoic acid	1	0.10 to 0.20††	(38)
	Trinitrobenzene	1	0.05††	(38)

Limiting Charges Necessary for Various Initiating Explosives.—(*Continued*)

Initiating explosive A	Explosive B against which tested	Amount of explosive B, g	Limiting charge of explosive A required for detonation of B, g	Lit.
Silver azide.—(*Cont'd*).......	TNT	1	0.05††	(38)
	Trinitroxylene	1	0.25††	(38)
Silver fulminate.	Tetryl	0.5	0.02	(26)
	Picric acid	0.5	0.05	(26)
	TNT	0.5	0.10	(26)
	Trinitroanisole	0.5	0.23	(26)
	Trinitroxylene	0.5	0.30	(26)

[*] The Rheinische-Westfälische Sprengstoff A. G. say that lead azide detonates satisfactorily with as much as 5 % of water.

[†] The Rheinische-Westfälische Sprengstoff A. G. say that pure fulminate and its mixtures do not detonate satisfactorily when containing 1 % water.

[‡] 0.24 in reinforced detonator.

[§] 0.25 in reinforced detonator.

[‖] In reinforced detonator.

[¶] At 200 atm.

[**] At 400 atm.

[††] Pressure 2000 kg/cm².

[‡‡] 0.2300 in reinforced detonator.

[§§] 0.2200 in reinforced detonator.

Detonation Velocity

Name	Det. vel., km/sec, V	Δ,* g/cm³	D,† mm	Notes	Lit.
Ammonium nitrate.......	1.46	0.83	25	1, 2	(20)
	1.31	0.84	25	1, 2	(20)
	1.47	0.83	26	1, 3	(20)
	1.23	0.69	50	1, 4	(20)
	1.25	0.65	50	1, 4	(20)
	1.49	0.68	80	1, 4	(20)
	1.50	0.66	80	1, 5	(20)
	1.53	0.79	80	1, 4	(20)
	1.55	0.88	80	1, 4	(20)
	2.70	0.98	80	1, 6	(20)
	1.92	0.64	100	1, 4	(20)
	1.83	0.84	100	1, 15	(20)
Ammonium perchlorate...	2.57	1.17	35	1, 7	(20)
	2.47	1.17	35	1, 7	(20)
	2.48	1.0	38	1, 8	(20)
Hexanitrodiphenylamine..	7.10	1.58	21	9, 10	(17)
	7.15	1.67	21		
Mannitol hexanitrate.....	8.26	1.73	12.8	‡	(20)
Mercury fulminate.......	3.00			Loose	(30)
	3.92		6.45		(4)
	2.25	1.25	Ordinary temp.		(23)
	2.35	1.25	−190°C		(23)
Nitroglycerin (in Mannesmann tube)............	8.00			liq.	(31)
	7.46	1.60	30		(19.5)
	1.53			liq.	(5)
	Det. not transmitted		6	11, 13 in 12	(7)
	0.65		9	13	(7)

Detonation Velocity.—(*Continued*)

Name	Det. vel., km/sec, V	Δ,* g/cm^3	D,† mm	Notes	Lit.
Nitroglycerin.—(*Cont'd*)	1.45 or 7.69		25	13	(7)
			25	14	(7)
	8.53		38	1, 13	(7)
(0.8 g detonator.)	2.02		38		(7); *cf.* (7.5)
(Det. fuse as primer)	7.23				
Picric acid	8.18	1.55	30		(3)
	7.25	1.63			(31)
	4.55	0.86			(14.5)
	6.16	1.34	21		(17)
	6.70	1.46	21		(17)
	7.00	1.53	21		(17)
	7.10	1.60	21		(17)
	7.26	1.69	21		(17)
	4.51	0.90	9.2		(8)
	5.10	0.94	20		(8)
	6.33	1.32	20		(8)
	6.94	1.46	20		(8)
	7.10	1.50	20		(8)
	7.37	1.62	20		(8)
	7.14	1.67	20		(8)
	7.49	1.72	20		(8)
In paper case	5.35	1.20	40		(11)
	5.71	1.40	40		(11)
	6.87	1.60	40		(11)
In Mannesmann tube	4.63	0.85	40		(11)
	5.21	1.20	40		(11)
Tetryl	7.15	1.53	21		(17, 18)
	7.16	1.59	21		(17, 18)
	7.20	1.63	21		(17, 18)
	7.25	1.63			(31)
Trinitrobenzene	6.27	1.33	21		(17, 18)
	6.30	1.35	21		(17, 18)
	6.94	1.56	21		(17, 18)
	7.00	1.60	21		(17, 18)
	7.00	1.64			(17, 18)
(Using various detonators and various amounts of dynamite as primer)	7.06	1.62			(8)
	7.35	1.64			(8)
	7.28	1.65			(8)
	7.35	1.66			(8)
	7.07	1.65			(8)
	7.00	1.53			(8)
	3.97	0.75	20		(8)
	3.81	0.62	20		(8)
	5.16	0.97	20		(8)
Trinitrochlorobenzene	6.80	1.66	21		(17)
(Pressed)	6.86	1.71	21		(17)
(Pressed)	7.13	1.75	21		(17)
(Cast)	7.15	1.76	29		(17)
Trinitrocresol	6.62	1.52	21		(17)
	6.85	1.62	21		(17)
Trinitrophenol	7.25	1.63			(30)
Trinitrophenylmethylnitroamine	7.52	1.63			

Detonation Velocity.—(*Continued*)

Name	Det. vel., km/sec, V	Δ,* g/cm^3	D,† mm	Notes	Lit.
Trinitrotoluene, paper covers	4.05	0.79	40		(11)
	5.24	1.22	40		(11)
	6.38	1.45	40		(11)
	6.87	1.59	40		(11)
In Mannesmann tube	4.74	0.85	40		(11)
	5.40	1.22	40		(11)
	6.29	1.45	40		(11)
	6.77	1.59	40		(11)
Various conditions of confinement	6.46	1.47	21		(17)
	6.70	1.59	29		(17)
	6.69	1.59	160		(17)
	6.22	1.32	20		(8)
	6.68	1.46	20		(8)
	6.88	1.56	20		(8)
	7.06	1.59	20		(8)
	7.14	1.60	20		(8)
	6.94	1.61	20		(8)
Trinitroxylene	6.60	1.51			(30)

* Bulk density in cartridge form.
† Cartridge or tube diam., mm.
‡ Free lying cartridge.

NOTES

1. In wrought iron tube. 2. Primer 50 g pressed tetryl. 3. Primer 60 g pressed tetryl. 4. Primer 100 g pressed picric acid. 5. Primer 300 g pressed picric acid. 6. Primer 250 g pressed tetryl. 7. Primer 110 g pressed tetryl. 8. Primer 25 g pressed picric acid. 9. 10 g picric acid and 1 g detonator. 10. Tamped with sand. 11. Glass tube. 12. Larger tube attached. 13. 1.6 g detonator. 14. Sheet iron tube. 15. Primer 200 g pressed tetryl.

COMPOUNDED EXPLOSIVES

BLASTING EXPLOSIVES

The following classification of blasting explosives will be found useful, though the classes are by no means mutually exclusive. *A.* Non-detonating explosives. *B.* Detonating or high explosives.

A. Non-detonating explosives.

Black powder is the principal type of this class. The German "Sprengsalpeter" is similar to black powder, with sodium nitrate in place of potassium nitrate.

B. Detonating or high explosives.

- I. Nitroglycerin explosives.
  - (*a*) Gelatinous explosives.
  - (*b*) Dynamites.
    - (1) With inactive additions.
    - (2) With active additions.
- II. Ammonium nitrate explosives containing as sensitizer:
  - (*a*) Nitroglycerin.
  - (*b*) Aromatic nitro body.
  - (*c*) Non-explosive substance.
- III. Perchlorate explosives.
- IV. Chlorate explosives.

Nitroglycerin explosives are liable to freeze and their use in the frozen condition gives rise to danger. This danger may be removed by partially or wholly replacing the nitroglycerin by nitrated chlorohydrin, ethyleneglycol dinitrate, dinitroglycerin, nitrated polyglycerin or aromatic nitro compounds such as nitrobenzene, thus forming low freezing (L. F.) explosives.

Some dynamites have a certain proportion of nitrocotton incorporated with the nitroglycerin to diminish the risk of exudation of the nitroglycerin during transport or storage. These may be called semi-gelatins. They resemble the dynamites rather than the gelatins in properties.

A special class of blasting explosives is constituted by those officially authorized for use in coal mines, which are often referred to as "safety explosives." They are known as "permitted explosives" in Great Britain, "permissible explosives" in the United States, "Wettersprengstoffe" in Germany, "Explosifs S. G. P., in Belgium, and "explosifs de sûreté" in France. They usually contain alkaline salts, or sometimes hydrated salts, to reduce the temperature of detonation, and the length and duration of flame.

COMPOSITIONS OF VARIOUS TYPICAL COMPOUNDED EXPLOSIVES
Blasting Explosives (*See* p. 495 for properties)

Key number	Explosive
1	**Black Powder:** KNO_3, 62–75.7%; S, 10–19.4%; charcoal, 12–5%. The properties can be modified to a considerable extent by varying the nature of the charcoal used, the time of mixing and the size of grain of the product.
2	**Bobbinite:** KNO_3, 65.31%; S, 2.63%; charcoal, 19.52%; paraffin, 3.35%; starch, 8.73%; H_2O, 0.46%.
3	**Blasting Gelatin:*** Nitroglycerin, 90–95%; nitrocotton, 5–10%.
4	**Nobel Gelatinous Explosives:*** Nitroglycerin, 25–85%; nitrocotton, 0.5–7%; liquid nitro body, 0.4–9%; woodmeal, 0.9–10%; K or Na nitrate, 6–45%; chalk, 0–0.3%.
5	**U. S. A. Gelatin Dynamites:*** L. F. Nitroglycerin, 20–80%; nitrocotton, 0.3–4.5%; combustible substances, 6–16%; $NaNO_3$, 1.5–6.2%; $CaCO_3$, 1%.
6	**French "Gommes":*** Nitroglycerin, 49–86%; nitrocotton, 2–6%; woodmeal, 0.25–10%; KNO_3, 4–36%.
7	**Kieselguhr Dynamite:**† Nitroglycerin, 72–75%; kieselguhr, 25–28%.
8	**Nobel Glasgow Dynamites (Semigelatinous):** Nitroglycerin, 24.4–57%; nitrocotton, 0.6–3.0%; $NaNO_3$, 21–55.75%; woodmeal, 16.5–19.25%.
9	**U. S. A. Straight Dynamites:** L. F. Nitroglycerin, 15–75%; $NaNO_3$, 5–66%; combustible substances, 5–20%; $CaCO_3$ or $MgCO_3$, 1%.
10	**Pittsburgh Standard 40% Straight Dynamite:** Nitroglycerin, 40%; $NaNO_3$, 44%; wood pulp, 15%; $CaCO_3$, 1%.
11	**Carbonites:** Nitroglycerin, 17–30%; $NaNO_3$, 24–30%; combustible (usually flour), 37–44%. Antacids are sometimes added, and the explosive may be made of the low freezing type by the use of tetranitrodiglycerin.
12	**Carbonite Type of Explosive Tested by U. S. A. Bureau of Mines (Explosive D):** Nitroglycerin, 24.92%; KNO_3, 25.37%; $Ba(NO_3)_2$, 4.42%; woodmeal, 34.60%; starch, 6.64%; H_2O, 4.05%.
13	**U. S. A. Ammonia Dynamites:** NH_4NO_3, 7–50%; $NaNO_3$, 14–60%; nitroglycerin, 12–25%; combustible substances, 8–20%; $CaCO_3$ or ZnO, 1%.
14A	**Grisoudynamite Couche:** NH_4NO_3, 87.5% (or 82.5% + KNO_3, 5%); nitroglycerin, 12%; nitrocotton, 0.5%.
14B	**Grisoudynamite Roche:** NH_4NO_3, 70% (or 65% + KNO_3, 5%); nitroglycerin, 29%; nitrocotton, 1%.
15	**Donarit:** NH_4NO_3, 80%; nitroglycerin (gelatinized or not), 4%; TNT, 12%; rye flour, 4%.
16A	**Grisounaphthalite Couche:** NH_4NO_3, 95% (or 90% + KNO_3, 5%); trinitronaphthalene, 5%.
16B	**Grisounaphthalite Roche:** NH_4NO_3, 91.5% (or 86.5% + KNO_3, 5%); dinitronaphthalene, 12%.
17	**Withnell Type of Explosive Tested by U. S. A. Bureau of Mines (Explosive J):** NH_4NO_3, 90.5%; TNT, 4.82%; flour, 4.23%; H_2O, 0.45%.
18	**Yonckites (Belgium):** NH_4ClO_4, 6–25%; NH_4NO_3, 17.5–65%; $NaNO_3$, 27–30%; $Ba(NO_3)_2$, 6–10%; TNT, 10–22.5% or TNN, 3.75%.
19	**Sabulex:** NH_4NO_3, 59–56%; $KClO_4$, 8–10%; TNT, 9–7%; NH_4Cl, 26–24%.
20	**Perchloratites (Germany):** The perchloratites authorized for use in Prussia include explosives with contents of $KClO_4$ ranging from 30–75%.
21	**Cheddites:** $KClO_3$, 70–90%; aromatic nitro compounds, 0–20%; paraffin, 0–14%.
22	**Cheddite Type Explosive Tested by U. S. A. Bureau of Mines (Explosive E)** · $KClO_3$, 75.36%; MNN, 1.3%; DNT, 17.85%; castor oil, 5.32%; H_2O, 0.17%.
23	**Silesia Type Explosive Tested by U. S. A. Bureau of Mines (Explosive F):** $KClO_3$, 75.27%; nitrated resin, 24.63%; H_2O, 0.10%.
24	**Chloratites (Germany):** The chloratites authorized for use in Prussia include explosives with contents of $KClO_3$ or $NaClO_3$ ranging from 70–91%, along with aromatic nitro derivatives and combustible substances.

Explosives For Use in Fiery Coal Mines

POWER

The power of British "permitted explosives" is measured by means of a ballistic pendulum test. A stemmed charge is fired electrically from a gun into a ballistic pendulum and the deflection is compared with that given by 4 oz. of 60% gelignite under the same conditions. The standard charge gives a swing of 3.27 in., and the actual deflections are reduced to correspond to this value. The values will be found in the "*Explosives in Coal Mines Orders.*"

The standard used in the United States is 40% straight dynamite. The unit deflective charge is that which gives the same deflection as 227 g (½ lb.) of the standard dynamite.

In Belgium a modified form of the Trauzl lead-block test is used for comparing the powers of S. G. P. explosives. The weight of explosive equivalent to 100 g of dynamite No. 1 is given. The values are published in the *Annales des Mines de Belgique.*

CHARGE LIMIT

For British "permitted" explosives the charge limits have in the past varied from 8 oz., to 40 oz., but are now fixed at the uniform figure of 28 oz. Results are published in the *Explosives in Coal Mines Orders.*

A general limit of 1½ lbs. is fixed for the maximum permissible charge of the U. S. A. "permissible explosives," and no explosive is placed on the list unless this maximum charge satisfies the gallery test.

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* Camphor, soda or chalk have also been added in small proportions, and sometimes a little nitro body.

† Sometimes soda, talc or heavy spar is added in small proportions.

Properties of Various Typical Compounded Explosives

Blasting explosives (*See* p. 494 for compositions)

Key number	Explosive	Heat of explosion, g-cal per g	Trauzl lead-block test, expansion in cm³	Fall-hammer test, weight of hammer 2 kg; fall, cm	Detonation velocity, meters per second	Loading density, g/cm³	Propagation of detonation by influence, cm	Diameter of cartridge, mm
1	Black powder	622–789 H_2O(l)	30	30–40	300–420 (rate of burning)	1.04–1.2		
2	Bobbinite*	623 H_2O(l)		>100	469	1.25		
3	Blasting gelatin	1530–1565 H_2O(g)	500–600	12–25	1500–2500 or 7200–8100	1.5–1.6		
4	Nobel gelatinous explosives		270–540		2300–5000 and up to 5000–9000	1.55–1.7		
5	U. S. A. gelatin dynamites				2100–2500 or 5000–7000			
7	Kieselguhr dynamite	1100–1300	300–370	7	1990–9700	Max., 1.67	30	32
9	U. S. A. straight dynamite	30%, 1025.8 60%, 1663.4	30% 190 60% 318		5%, 1294 60%, 5800–6000	20% 1.18		
10	Pittsburgh Standard 40% straight dynamite	1221.4	278	10	4688	1.22	43.2	32
11	Carbonites (U. S. A.)	573–770	120–185	6–13	2285–3470	0.98–1.33	7.5–2.3	32
12	Carbonite type (Explosive D)*	570.7	156	13	2589	0.68	10.2	32
13	U. S. A. ammonia dynamites	40%, 1122	40%, 202		3010–4380 40%, 3157	40%, 1.57		
14A	Grisoudynamite couche	783					3.7	30
14B	Roche	978					8.2	30
	Roche sâlpetrée	870						
15	Donarit	930–1220	375–400	30–160	3700–4150		2.7	30
16A	Grisounaphthalite couche				2460–3240 (according to diam. of cartridge)			
	Couche sâlpetrée	816						
16B	Roche						3.9	30
17	Withnell type (explosive J)*	1285.5	245	100	3971	0.94	7.6	32
21	Cheddites	1065–1185	210–280	14–36	2100–3100 (according to density)	13–1.6		
22	Cheddite type (explosive E)*	1065.1	212	23	2771	1.28	7.6	32
23	Silesia type (explosive F)*	865.5	201	3	2722	1.04		

* Tested by U. S. A. Bureau of Mines.

The charge limits for Belgian S. G. P. explosives vary from 400 g to 900 g. The values are published in the *Annales des Mines de Belgique*.

The charge limits fixed in the Prussian official regulations for the use of "Wettersprengstoffe" are 700 or 800 g, separate limits being fixed for fiery and non-fiery mines. In the great majority of cases the limit is 800 g in each case. *See* "Das Sprengstoffwesen im preussischen Bergbau."

DETONATION VELOCITY

The detonation velocities of U. S. A. permissible explosives vary from 1792 meters per second for Red H.C. L.F. to 4651 for Gelobel.

Values are not published by the authorities in Great Britain The detonation velocities of the permitted explosives made by Nobel Industries Limited range from 1900 to 5000 meters per second.

Propulsive Explosives

Propulsive explosives may be arranged under the following classes:

1. Black powder type.
2. Nitrocellulose powders.
    (*a*) Without additions.
    (*b*) With additions.

3. Nitroglycerin powders containing both nitrocellulose and nitroglycerin.

(a) Without other additions.

(b) With other additions.

Examples are given showing the composition and properties of various compounded explosives.

Black Powder, *see* Blasting Explosives.

Amide Powder (Chilworth Special Powder): NH_4NO_3, 35.38%; KNO_3, 40–46%; charcoal, 14–22%.

Ammonpulver: NH_4NO_3, 80–90%; charcoal, 10–20%.

Nitrocellulose Powders

American Pyrocollodion Powders: nitrocellulose 99.4% (mixture of di- and trinitrocellulose, average nitrogen content 12.60%), diphenylamine. Together with residual solvent and water 0.6%.

French B Powder: CP_2, 20–25% to 50–55% according to the liveliness of the powder, along with CP_1. The solvent used is ether-alcohol. Amyl alcohol or diphenylamine may be used as stabilizer. These are indicated by AM or D after the name. CP_1 is a nitrocotton with nitrogen content of about 13%. About 10% (<15%) is soluble in ether-alcohol. It gives off 205–214 cm³ of N_2O_4/g in nitrometer test. CP_2 is a nitrocotton with nitrogen content of about 12%, almost completely soluble in ether-alcohol (>96%) and giving off 190–198 cm³ of N_2O_4 per g in nitrometer.

Walsrode Shotgun Powder: Nitrocellulose, 97%; chalk, 2%; ether, 1%.

Nitrocellulose Powders with Additions

Amberite:* Nitrocellulose (insoluble, 18.6%, soluble, 46%); mineral nitrates, 2.8%; vaseline, 6%; H_2O, 1.4%.

Clermonite: Nitrocellulose with mineral nitrates.

E. C. Powder: Contains from 14% of mineral nitrates and vaseline, camphor, resin and woodmeal or some of them in addition to nitrocellulose.

Empire Powder: Contains mineral nitrates, 9%, and vaseline in addition to nitrocellulose.

Hasloch Jagdpulver: Contains $Ba(NO_3)_2$, 17%, and vaseline in addition to nitrocellulose.

J. Powder (French): Contains $(NH_4)_2Cr_2O_7$, 14%, and $K_2Cr_2O_7$, 3%, in addition to nitrocellulose.

T. Powder (French): Contains 2% KNO_3 in addition to nitrocellulose, CP_1 gelatinized with acetone.

S. Powder:† CP_1, 37%; CP_2, 28%; $Ba(NO_3)_2$, 29%; KNO_3, 6%.

Rottweil Smokeless Powder (Shotgun): Insoluble nitrocellulose, 72.3%; soluble nitrocellulose, 24.5%; camphor and diphenylamine, 1%; H_2O, 1.5%; metallic nitrates, 0.7%.

Rottweil Smokeless Powder (Rifle): Insoluble nitrocellulose, 72.8%; soluble nitrocellulose, 25.0%; camphor and diphenylamine, 1%; H_2O, 1.2%.

Nitroglycerin Powders

Ballistite:‡ Guncotton, 50%; nitroglycerin, 49%; diphenylamine, 1%.

Ballistite, Norwegian: Guncotton, 50%; nitroglycerin, 40%; nitronaphthalene, 5%; diamyl phthalate, 5%.

Sporting Ballistite: Nitrocellulose, 60.5%; nitroglycerin, 39.5%.

Cordite Mk. I: Guncotton, 37%; nitroglycerin, 58%; mineral jelly, 5%; H_2O, 0.5%.

Cordite M. D.: Guncotton, 65%; nitroglycerin, 30%; mineral jelly, 5%; H_2O, 0.5%.

Cordite R. D. B.: Nitrocotton (N = 12.2%), 52%; nitroglycerin, 42%; mineral jelly, 6%.

Nitroglycerine Powders with Additions

Köln-Rottweil TNT powder: Nitrocellulose, 61%; nitroglycerin, 20%; TNT, 15%; DNT, 3.5%; centralite, 0.5%.

Allestite: Nitrocellulose, 60%; nitroglycerin, 25%; DNT, 15%.

Austrian Flake Powder No. 1: Nitrocellulose, 36%; nitroglycerin, 36%; $Ba(NO_3)_2$, 18%; charcoal, 10%.

Austrian Flake Powder No. 2 (Graphited): Nitrocellulose, 40%; nitroglycerin, 40%; $Ba(NO_3)_2$, 20%.

Wetteren Smokeless Powder:* Nitrocellulose, insoluble, 16%, soluble, 46.2%; nitroglycerin, 27.3%; charcoal, 9%; H_2O, 1.5%.

In the application of propulsive explosives the nature of the weapon, the velocity of the projectile, and the maximum permissible pressure in the barrel are usually fixed, and the powder is modified in composition or physical properties to give the ballistics demanded.

The following table from an article by MacNab and Leighton (24) gives the heat of explosion and the volume and composition of the explosion gases for a number of sporting powders.

Properties of Some Sporting Powders (24)

Powder	Heat of explosion, g-cal/g	Permanent gases per g, cm³	Water vapor per g, cm³	Total volume of gas at 0°C and 760 mm, cm³ per g	Composition of permanent gases, %				
					CO_2	CO	CH_4	H	N
Imperial Schultze	742	763	152	915	8.9	52.7	1.0	27.0	10.4
Amberite	745	635	156	791	12.0	50.0	0.4	25.5	12.1
S. S.	755	695	131	816	11.8	51.3	0.8	23.7	12.4
E. C.	762	718	158	876	11.9	52.1	0.5	23.9	11.6
Schultze	786	576	160	736	15.5	46.7	0.8	23.0	14.0
Kynoch's smokeless	807	600	126	726	14.8	49.5	0.7	18.8	16.2
Cannonite	845	725	146	871	14.6	49.9	0.6	22.2	12.7
Shotgun Rifleite	896	705	169	874	19.0	45.3	0.8	21.5	13.4
Walsrode	1014	669	206	875	21.3	48.2	0.4	10.1	14.8
Cordite M. D.	1031	726	215	941	16.3	50.4	0.0	19.7	13.6
Cordite	1253	647	235	882	24.9	40.3	0.7	14.8	19.3
Sporting Ballistite	1286	591	234	825	32.2	37.1	0.4	10.1	20.2

Standard Ballistics for Shotgun Powders

A. TYPICAL AMERICAN STANDARD PROOF

Lead crushers are used, the Eley 1913 tables being employed to calculate the pressures from the remaining length.

The following are the average ballistics aimed at for various typical powders. They refer to matured powder containing $1\frac{1}{8}$% moisture.

Charges	Velocity over 40 yards = V_{20} yd. or $V_{18.3}$ M	Pressure at 1 in. (2.54 cm) from base
Smokeless Shotgun		
3 drams powder = about 5.30 g. $1\frac{1}{8}$ oz. = 31.89 g shot. $2\frac{5}{8}$ in. flat base case.	875 ft./sec = 307.38 m/sec	3.5 ton/in.² = 551.2 kg/cm²
$3\frac{1}{2}$ drams powder = about 6.20 g. $1\frac{1}{4}$ oz. = 35.44 g shot. $2\frac{3}{4}$ in. flat base case.	925 ft./sec = 282 m/sec	$4\frac{3}{4}$ ton/in.² = 748 kg/cm²
E. C. and Schultze Powders		
3 dram charge = 5.30 g. $1\frac{1}{8}$ oz. = 31.89 g shot. $2\frac{5}{8}$ in. flat base cases.	870 ft./sec = 265.2 m/sec	
$3\frac{1}{2}$ drams charge = 6.20 g. $1\frac{1}{4}$ oz. = 35.44 g shot. $2\frac{3}{4}$ in. flat base cases.	890 ft./sec = 271.3 m/sec	4.1–4.5 ton/in.² = 645.7–718.7 kg/cm²

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* Fibrous 42 % grain bulk.

† Partially gelatinized with ether-alcohol

‡ Gelatinized with acetone.

* Gelatinized with rifle powders.

Typical British Standard Proof

Lead crushers are used, the Eley 1918 Tables being employed to calculate the pressures from the remaining length. Pressure: 2½–3 ton/in.^{2} = 393.7 – 472.5 kg/cm.^{2} Velocity over 20 yards = V_{10} yd. or $V_{9.15}$ m = 320–335 m/sec.

Charges Which Give Standard Ballistics

Powder	Caliber	Length of cartridge case		Powder charge, wt.		Shot charge, wt.	
		in.	mm	grains	g	ounces	g
Smokeless Diamond E. C. Empire in flat base cases, 3 drams = 33 grains	12	$2\frac{3}{4}$	70	36	2.33	$1\frac{1}{4}$	35.44
	12	$2\frac{1}{2}$	65	33	2.14	$1\frac{1}{16}$	30.12
	16	$2\frac{3}{4}$	70	31	2.01	1	28.35
	16	$2\frac{1}{2}$	65	28	1.81	$\frac{7}{8}$	24.81
Schultze Amberite in flat base cases, 3 drams = 42 grains	12	$2\frac{3}{4}$	70	46	2.98	$1\frac{1}{4}$	35.44
	12	$2\frac{1}{2}$	65	42	2.72	$1\frac{1}{16}$	30.12
	16	$2\frac{3}{4}$	70	40	2.59	$1\frac{1}{16}$	30.12
	16	$2\frac{1}{2}$	65	36	2.53	$\frac{7}{8}$	24.81
Ballistite condensed powder in cone base cases	12	$2\frac{3}{4}$	70	28	1.81	$1\frac{1}{4}$	35.44
	12	$2\frac{1}{2}$	65	25	1.62	$1\frac{1}{16}$	30.12
	16	$2\frac{3}{4}$	70	23	1.49	1	28.35
	16	$2\frac{1}{2}$	65	21	1.36	$\frac{7}{8}$	24.81
				drams			
Black powder in flat base cases, 3 drams = 84 grains	12	$2\frac{3}{4}$	70	$3\frac{1}{4}$	5.75	$1\frac{1}{4}$	35.44
	12	$2\frac{1}{2}$	65	3	5.30	$1\frac{1}{8}$	31.89
	16	$2\frac{3}{4}$	70	3	5.30	1	28.35
	16	$2\frac{1}{2}$	65	$2\frac{3}{4}$	4.87	$\frac{7}{8}$	24.81

The bulk density of the 33 grain powders is 375–385 g per liter.
The bulk density of the 42 grain powders is 475–485 g per liter.
The bulk density of Sporting Ballistite is 700–710 g per liter.

Rifle Powders

For rifle powders there are no fixed standard ballistics such as have been established for shotgun powders. As an example some data are given for the 7 mm Mauser rifle.

7 mm Mauser Rifle

Powder	Powder charge, grains	Weight of bullet, grains	Muzzle velocity, ft./sec	Pressure
American Military Rifle powder (*a*)...	48	139	2900	Best burning pressure, 3515–3967 kg/cm^2
(*b*)..........	42.5	139	2750	2109–3151 kg/cm^2
	44.0	139	2900	
(*c*)..........	36.9	175	2300	2320–2671 kg/cm^2
	40	175	2400	
	44	139	2786	
	45.5	139	2950	
(*d*)..........	5.0	84	950	703–1055 kg/cm^2
	8.0	120	1150	
British Rifle Neonite..........	38	173	2300	Pressure aimed at: 17.5 ton/in.^{2}
	43	140	2800	19.5 ton/in.^{2}

Ordnance Powder

Here also, as in the case of rifle powders, the ballistic values required are fixed in advance, and the powder is modified in composition, in size and shape of grain, or by coating to modify its rate of burning. Examples are given of ballistics for the 7.5 cm field gun.

7.5 cm Field Gun

Gun	Powder charge, kg	Weight of projectile, kg	Muzzle velocity, m/sec	Range, km
U. S. A., 75 mm (Model 1923)....		6.8	665	13.5
Switzerland........		6.35	250–485	8.6
France............		7.25 (shrapnel)	550	11
		7.98 (H. E. shell)		
Japan (Model 05)..	0.631	6.8 (shrapnel)	510	5.8
	0.631	6.4 (H. E. shell)		8.35

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112. Dinglers polytechnisches Journal.
113. Berichte der technisch-wissenschaftliche Abteilung deg Vereins keramische Gewerbe im Deutschland.
114. Electric Journal.
115. Engineering.
116. Sibley Journal of Engineering.
117. Scientific Proceedings of the Royal Dublin Society.
118. Annales de l'institut polytechnique du Don, Novocerkask.
119. Proceedings of the American Institution of Electrical Engineers. (*Discontinued in 1919.*)
120. General Electric Review.
121. Electrician.
122. Journal of the American Society of Mechanical Engineere. (*See* No. 56.)
123. British Clayworker.
124. Silikat-Zeitschrift.
125. Archiv für Elektrotechnik. (*Supplement to* No. 101.)
126. Bulletin de la société française des électriciens.
127. Elettrotecnica.
128. Journal of the Washington Academy of Sciences.
129. Transactions of the American Institute of Electrical Engineers.
130. Technische Studien.
131. American Journal of Physiology.
132. Anales de la sociedad española de física y química.
133. British Association for the Advancement of Science, Reports.
134. Bulletin de l'académie des sciences de l'union des républiques soviétiques socialistes. (*Formerly* Bulletin de l'académie impérial des sciences de St. Pétersbourg; *name changed in 1917 to* Bulletin de l'académie des sciences de Russie; *present name dates from 1925.*)
135. Chemical News and Journal of Industrial Science. (*Name changed in 1921 from* Chemical News and Journal of Physical Science.)
136. Chemiker-Zeitung.
137. Kongelige Danske Videnskabernes Selskab. Mathematisk-fysiske Meddelelser.
138. Societas scientiarum fennica. Commentationes physico-mathematicae.
139. Ferrum.
140. Journal of the Iron and Steel Institute, London.
141. Journal of Biological Chemistry.

142. Journal of the Society of Chemical Industry, Japan. (*Formerly* Journal of Chemical Industry, Japan.)
143. Journal of The Franklin Institute.
144. Mathematikai ès Természettudományi Ertesitö, Budapest.
145. Zeitschrift für Biologie.
146. Zement und Beton.
147. Meddelanden från K. Vetenskapsakademiens Nobelinstitut.
148. Zeitschrift für die gesamte Kälte-Industrie.
149. Archives des sciences physiques et naturelles. (Bibliothèque britannique, 1796–1815; Bibliothèque universelle des sciences, belles-lettres et arts, 1816–1835; Bibliothèque universelle de Genève 1836–1845; Supplément à la bibliothèque universelle de Genève. Archives des sciences physiques et naturelles, 1846–1847; Bibliothèque universelle de Genève. Archives des sciences physiques et naturelles, 1848–1857; Bibliothèque universelle, revue suisse et étrangère. Archives des sciences physiques et naturelles, 1858–1861; Bibliothèque universelle et revue suisse. Archives des sciences physiques et naturelles, 1862–1867; Bibliothèque universelle. Archives des sciences physiques et naturelles, 1878– .)
150. Mitteilungen über Forschungsarbeiten auf dem Gebiete des Ingenieurwesens insbesondere aus dem Laboratorium der technischer Hochschulen. Verein deutscher Ingenieure.
151. Mémoires de l'académie royale des sciences de l'institut de France.
152. Carnegie Institution of Washington, Publications.
153. Minutes of Proceedings of the Institution of Civil Engineers.
154. Iowa Geological Survey, Bulletin.
155. Missouri Bureau of Geology and Mines.
156. U. S. Geological Survey, Bulletin.
157. U. S. Department of Agriculture, Bulletin.
158. New York State Museum, Bulletin.
159. Science Reports of the Tôhoku Imperial University. Series I, Mathematics, Physics and Chemistry.
159B. Science Reports of the Tôhoku Imperial University. Series III, Petrology, Mineralogy and Mineral Deposits.
160. Arkansas Geological Survey, Annual Reports.
161. Mitteilungen aus dem königlichen technischen Versuchsanstalten zu Berlin. (*See also* No. 312.)
162. Mitteilungen aus dem Mechanisch-technischen Laboratorium der technischen Hochschule in München.
163. Minnesota Geological and Natural History Survey.
164. Colorado, Biennial Report Capitol Managers.
165. Bulletin internationale de l'académie des sciences de Cracovie. (*Name changed to* Bulletin internationale de l'académie Polonaise des sciences et des lettres.)
166. Science.
167. Jahresbericht über die Fortschritte der Chemie und verwandte Theile anderer Wissenschaften.
168. Communications from the Physical Laboratory at the University of Leiden.
169. Annales de l'Institut Polytechnique Pierre-le-Grand, Pétrograd.
170. Memorie della reale accademia nazionale dei Lincei, Roma.
171. Sitzungsberichte der Heidelberger Akademie der Wissenschaften. Mathematisch-naturwissenschaftliche Klasse. Abteilung A.
172. International Congress of Applied Chemistry.
173. Analyst, London.
174. Transactions of the Royal Society of Edinburgh.
175. Annales academiae scientiarum fennicae.
176. Chemisch Weekblad, Amsterdam.
177. Annales scientifiques de l'université de Jassy.
178. Archivio di fisiologia (Florence).
179. Nachrichten (Iswesti) des Polytechnikums, Petrograd.
180. Anzeiger der Akademie der Wissenschaften, Krakau.
181. Travaux de la société de physique et de chimie de Kharkoff.
182. Proceedings of the Chemical Society, London.
183. Annales de l'Institut électrotechnique Alexander III, Pétrograd.
184. American Journal of Pharmacy.
185. Chemisches Zentralblatt.
186. Bulletin de la classe des sciences, académie royale de Belgique.
187. Metall und Erz, Zeitschrift für Metallhüttenwesen und Erzbergbau, einschl. Aufbereitung.
188. Nachrichten von der königlichen Gesellschaft der Wissenschaften zu Göttingen. Geschaftliche Mitteilungen; mathematisch-physikalische Klasse.
189. Centralblatt für Mineralogie, Geologie und Paläontologie.
190. Neues Jahrbuch für Mineralogie, Geologie und Paläontologie.
190B. Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, Beilage Band.
191. Bulletin de la société française de minéralogie.
192. Metallurgie. (*Divided into* Nos. 139 and 187.)
193. Mitteilungen der Naturforschenden Gesellschaft zu Halle.
194. Journal of the Science Association, Maharajah's College.
195. Sitzungsberichte der Dorpater Naturforscher-Gesellschaft an der Universität.
196. Sammlung chemischer und chemisch-technischer Vorträge.
197. Proceedings of the National Academy of Sciences.
198. Revue générale des sciences pures et appliquées.
199. Le Radium. (*Merged into* No. 51 *in 1920.*)
200. Jahrbuch der Radioaktivität und Elektronik. (*Combined with* No. 63 *in 1924.*)
201. Proceedings of the Cambridge Philosophical Society.
202. Zeitschrift für physiologische Chemie.
203. Archiv für Anatomie und Physiologie. Physiologische Abteilung. (*Merged with* No. 278.)
204. Photographic Journal.
205. Biochemische Zeitschrift.
206. Comptes rendus des séances de la société de biologie.
207. Geologiska Föreningen i Stockholm, Förhandlingar.
208. Physica, Nederlandsch Tijdschrift voor Natuurkunde.
209. Japanese Journal of Chemistry.
210. Scientific Papers, Institute of Physical-Chemical Research. Tokyo.
211. Abhandlungen der sächsischen Akademie der Wissenschaften zu Leipzig. Mathematisch-physischen Klasse.
212. Transactions of the American Society for Steel Treating.
213. Sitzungsberichte der bayerischen Akademie der Wissenschaften zu München. Mathematisch-physikalischen Klasse.
214. Kongelige Danske Videnskabernes Selskab, Skrifter naturvidenskabelig og mathematisk Afdeling.
215. Lunds Universitets Årsskrift.
216. Giornale di chimica industriale ed applicata. (Annali di chimica applicata, *1914; continued as* Giornale di chimica applicata; *combined with* Giornale di chimica industriale, *March, 1920, to form* Giornale di chimica industriale ed applicata.)
217. U. S. Coast and Geodetic Survey, Special Publications.
218. Naturwissenschaften.
219. Proceedings of the Physico-Mathematical Society of Japan.
220. Jern-Kontorets Annaler, Stockholm.
221. Berichte der sächsischen Akademie der Wissenschaften zu Leipzig. Mathematisch-physische Klasse.
222. Giornale di mineralogia, cristallografia e petrografia.
223. Journal of General Physiology.
224. Kosmos, Stockholm.
225. Kosmos. (Polskie towarzystwo przyrodników imienia Kopernika.) Lemberg.
226. Mitteilungen aus dem Kaiser-Wilhelm-Institut für Eisenforschung zu Düsseldorf.

227. Proceedings of the Society for Experimental Biology and Medicine.
228. Denkschriften der kaiserlichen Akademie der Wissenschaften zu Wien. Mathematisch-naturwissenschaftliche Klasse.
229. Journal of Bacteriology.
230. Biochemical Journal.
231. U. S. Public Health Service, Public Health Reports.
232. Soil Science.
233. Pharmaceutisch Weekblad.
234. Journal of the South African Chemical Institute. (*Name changed in 1922 from* Journal of the South African Association of Analytical Chemists.)
235. Comptes-rendus des travaux du laboratoire Carlsberg.
236. Ergebnisse der Physiologie.
237. Fortschritte der Chemie, Physik und physikalischen Chemie.
238. Travaux et mémoires du bureau international des poids et mesures.
239. Nouveaux mémoires de l'académie royale des sciences, des lettres et des beaux-arts de Belgique, Brussels.
240. Bibliothèque universelle des sciences, belles-lettres et arts. (*Continued as* No. 149.)
241. Proceedings of the American Philosophical Society.
242. Vierteljahrsschrift der naturforschenden Gesellschaft, Zürich.
243. Zeitschrift für Instrumentenkunde.
244. Journal of the Society of Automotive Engineers.
245. Zeitschrift für das gesamte Schiess- und Sprengstoffwesen.
246. Ice and Refrigeration.
247. Chemist-Analyst.
248. Proceedings of the University of Durham Philosophical Society.
249. Fortschritte auf dem Gebiete der Röntgenstrahlen.
250. Bulletin de séances de la société française de physique (1873–1910). (*From 1873–1901 as its* Séances; *continued as* No. 51.)
251. Proceedings of the Royal Society of Victoria, Melbourne.
252. Chemische Umschau auf dem Gebiete der Fette, Oele, Wachse und Harze. (*Before 1916* Chemische Revue über die Fett- und Harz-Industrie.)
253. Lubrication.
254. Zeitschrift für Beleuchtungswesen, Heizungs- und Lüftungstechnik.
255. Bulletin of the American Institute of Mining and Metallurgical Engineers. (*Continued as* No. 329.)
256. Comptes rendus de la société scientifique, Warsaw.
257. Bulletin of the Imperial Institute, London. (*Before 1903,* Imperial Institute Journal.)
258. Le cuir. Edition technique. (*Name changed Nov., 1923 to* Le cuir technique.)
259. Collegium.
260. Indian Forest Records.
261. Journal of the American Leather Chemists' Association.
262. Journal of the International Society of Leather Trades' Chemists. (*Before Oct., 1925,* Journal of the Society of Leather Trades' Chemists.)
263. Leather Trades' Review.
264. Ledertechnische Rundschau. (*Technical supplement of* Der Lederindustrie.)
265. Queensland Agricultural Journal.
266. Indianapolis Medical Journal.
267. Philippine Journal of Science.
268. Terrestrial Magnetism.
269. Mineralogical Magazine and Journal of the Mineralogical Society.
270. Berichte der naturforschenden Gesellschaft zu Freiburg, im Breisgau.
271. Revue scientifique.
272. Transactions of the Wisconsin Academy of Sciences, Arts and Letters.
273. Berichte der deutschen pharmazeutischen Gesellschaft. (*See also* No. 293.)
274. Pharmazeutische Zentralhalle für Deutschland.
275. International Sugar Journal.
276. Chemical Age, London.
277. Archiv für experimentelle Pathologie und Pharmakologie.
278. Archiv für die gesamte Physiologie des Menschen und der Tiere. (Pflüger.)
279. Zeitschrift für Untersuchung der Lebensmittel. (*Formerly* Zeitschrift für Untersuchung der Nahrungs- und Genussmittel sowie der Gebrauchsgegenstande.)
280. Umschau.
281. Zeitschrift für Psychologie und Physiologie der Sinnesorgane.
282. Wochenschrift für Brauerei.
283. Journal de psychologie normal et pathologique.
284. Journal of the American Pharmaceutical Association.
285. Journal of Mathematics and Physics (Massachusetts Institute of Technology).
286. Chemical Reviews.
287. Kolloidchemische Beihefte.
288. Revue générale des colloides et de leurs applications industrielles.
289. Journal of Physiology.
290. Journal of the Society of Dyers and Colourists.
291. Arbeiten aus dem Reichsgesundheitsamte.
292. Proceedings and Transactions of the Nova Scotian Institute of Science.
293. Archiv der Pharmazie. (*Combined with* No. 273 *in 1924 to form* Archiv der Pharmazie und Berichte der deutschen pharmazeutischen Gesellschaft.)
294. Mémoires de l'académie de Belgique.
295. Proceedings of the American Wood-Preservers' Association.
296. Kunststoffe, Zeitschrift für Erzeugung und Verwendung veredelter oder chemisch hergestellter Stoffe.
297. National Advisory Committee on Aeronautics. Technical Reports.
298. National Advisory Committee on Aeronautics. Technical Notes.
299. British Aeronautical Research Committee. Reports and Memoranda.
300. British Advisory Committee on Aeronautics. Reports and Memoirs.
301. Jahrbuch der Motorluftschiff-Studiengesellschaft.
302. Smithsonian Institution Publications. Miscellaneous Collection.
303. Bulletin de l'institut aérodynamique de Koutchino, Pétrograd.
304. Aerodynamische Versuchsanstalt zu Göttingen. Ergebnisse.
305. Transactions of the American Society of Civil Engineers.
306. Journal of the American Society of Naval Engineers.
307. Iron and Coal Trades Review.
308. Fortschritte der Mineralogie, Kristallographie und Petrographie.
309. Bulletin of the Lewis Institute, Structural Materials Research Laboratory, Chicago.
310. Transactions of the National Lime Manufacturers' Association.
311. France-Belgique. (Revue de l'ingénieur et index technique *merged with this in 1922.*)
312. Mitteilungen aus dem Materialprüfungsamt und dem Kaiser-Wilhelm-Institut für Metallforschung zu Berlin-Dahlem. (Mitteilungen aus dem königlichen technischen Versuchsanstalten zu Berlin, 1883–1903; *in 1904 became* Mitteilungen aus dem königlichen Materialprüfungsamt zu Gross-Lichter-

felde West; *later becoming* Mitteilungen aus dem königlichen Materialprüfungsamt zu Berlin-Lichterfelde West; *name changed in 1919 to* Mitteilungen aus dem Materialprüfungsamt zu Berlin-Lichterfelde West; *name changed in 1920 to* Mitteilungen aus dem Materialprüfungsamt zu Berlin-Dahlem; *present name dates from 1923.*)

313. U. S. Bureau of Mines, Reports of Investigations.
314. Tonindustrie-Zeitung.
315. Mémorial des poudres. (*Formerly* Mémorial des poudres et salpêtres.)
316. Journal and Proceedings of the Royal Society of New South Wales.
317. Chemische Industrie. (*Combined with* No. 92 *in 1921; separated again in 1923.*)
318. Journal of the Indian Institute of Science.
319. Die deutsche pharmazeutische Zeitung.
320. Journal of Analytical and Applied Chemistry. (*Merged into* No. 1 *in 1893.*)
321. Transactions of the Royal Dublin Society.
322. Schriften der Dorpater Naturforscher-Gesellschaft an der Universität.
323. Jahrbuch der königlichen kaiserlichen geologischen Reichsanstalt.
324. Canadian Chemistry and Metallurgy.
325. Proceedings of the Royal Institution of Great Britain.
326. Astronomical Journal.
327. Annales de la société scientifique de Bruxelles.
328. American Mineralogist.
329. Mining and Metallurgy. (Transactions of the American Brass Founders' Association, 1908–11; Transactions of the American Institute of Metals, 1912–16; Journal of the American Institute of Metals, 1917–18; *discontinued in 1918 and incorporated with* Bulletin of the American Institute of Mining Engineers; *with issue No. 148, 1919, this Bulletin became* Bulletin of the American Institute of Mining and Metallurgical Engineers; *with issue No. 154, 1919, name changed again to* Mining and Metallurgy.)
330. Psychological Monographs.
331. Archives of Psychology.
332. Philosophische Studien.
333. Psychological Review.
334. Journal of Experimental Psychology.
335. American Journal of Psychology.
336. Bulletin of the Geological Society of America.
337. Bulletin of the National Research Council.
338. Researches of the Electro-Technical Laboratory (Tokyo).
339. American Journal of Mathematics.
340. Philippine Agriculturist.
341. Journal of Agricultural Research.
342. Annales de chimie analytique et de chimie appliquée et revue de chimie analytique réunies.
343. Zeitschrift für öffentliche Chemie. (*Suspended at end of 1922.*)
344. Apotheker Zeitung.
345. Bulletin des sciences pharmacologiques.
346. Malayan Agricultural Journal. (*Formerly* Bulletin of the Department of Agriculture, Federated Malay States.)
347. Pharmaceutical Journal and Pharmacist.
348. Cotton Oil Press.
349. Seifensieder-Zeitung und Rundschau über die Harz-, Fett- und Ölindustrie mit dem Beiblatt: Der chemisch-technische Fabrikant.
350. Les matières grasses.
351. Journal of State Medicine, London.
352. Milchwirtschaftliche Zentralblatt. (*Name changed in 1912 from* Milch-Zeitung.)
353. Academia caesarea leopoldino carolina germanica naturae curiosorum.
354. National Physical Laboratory, Collected Researches and Reports, London.
355. The Engineer, London.
356. Journal of the Royal Society of Arts.
357. Anales de la asociación química Argentina. (*Name changed Jan., 1921, from* Anales de la sociedad química Argentina.)
358. Journal of the Institution of Petroleum Technologists and Record of Transactions.
359. Petroleum Age. (Petroleum; *name changed to* Petroleum Magazine, *and then back to* Petroleum; *in Sept., 1921, combined with* Petroleum Age *to form* Petroleum Age including Petroleum; *name changed back to* Petroleum Age, *Dec., 1925.*)
360. National Petroleum News.
361. Petroleum, Zeitschrift für die gesamten Interessen der Mineralöl-Industrie und des Mineralöl-Handels. (*Formerly* Petroleum, Zeitschrift für die gesamten Interessen der Petroleum-Industrie und des Petroleum-Handels.)
362. Chemické Listy pro vědu a Prumysl.
363. Petroleum Review. (*Replaced by* No. 364.)
364. Petroleum Times. (*See* No. 363.)
365. Bureau of Standards, Circulars.
366. Feuerungstechnik.
367. Oesterreichische Chemiker-Zeitung.
368. Proceedings of the Institution of Automobile Engineers, London.
369. Gornyĭ zhurnal.
370. Memoirs of the American Academy of Arts and Sciences, Boston.
371. University Geological Survey of Kansas, Reports.
372. Verein zur Beförderung des Gewerbefleisses, Verhandlungen.
373. Chemisch-technisches Repertorium. (*Supplement to* No. 136.)
374. Oil and Colourman's Journal.
375. Polytechnisches Centralblatt.
376. Automotive Industries.
377. Bulletin de la section scientifique de l'académie Roumaine.
378. Chimie et industrie.
379. Journal of the Japanese Ceramic Society.
380. Gesundheits-Ingenieur.
381. Automobile Engineer and Internal Combustion Engineering. (Automobile Engineer, London, *1910 to Oct., 1912:* Internal Combustion Engineering, *Oct., 1912, to Jan., 1914; present name since Jan., 1914.*)
382. Refrigerating Engineering. (Transactions of the American Society of Refrigerating Engineers, *1905–13;* American Society of Refrigerating Engineers Journal; *present name dates from July, 1922.*)
383. Revue générale du froid et des industries frigorifiques.
384. Le génie civil, Paris.
385. Journal of the American Society of Heating and Ventilating Engineers.
386. Canada Department of Mines.
387. Mineral Industry.
388. Öfversigt af kongl. Svenska Vetenskaps-Akademien, Förhandlingar.
389. South African Journal of Industries. (*United with the* Official Labour Gazette of the Union of South Africa *in 1925 to form the* South African Journal of Industries and Labour Gazette.)
390. Indian Forest Bulletin.
391. Indian Forester.
392. Indian Forest Pamphlet.
393. American Society for Testing Materials, Standards.

394. Fuel in Science and Practice.
395. Engineering and Mining Journal-Press. (*Formed in April, 1922 by the combining of* Engineering and Mining Journal *with* Mining and Scientific Press; *name changed July, 1926, to* Engineering and Mining Journal.)
396. Gas Journal. (*Formerly* Journal of Gas Lighting and Water Supply.)
397. Gas- und Wasserfach. (*Name changed Jan., 1922, from* Journal für Gasbeleuchtung und verwandte Beleuchtungsarten sowie für Wasserversorgung.)
398. Memoirs and Proceedings of the Manchester Literary and Philosophical Society.
399. Colliery Guardian and Journal of the Coal and Iron Trades.
400. Beama.
401. Revue de l'industrie minérale. (Bulletin de la société de l'industrie minérale; *name changed Jan., 1921, to* Revue de la société de l'industrie minérale; *name changed to* Revue de l'industrie minérale.)
402. Technique moderne.
403. Proceedings of the Institution of Mechanical Engineers.
404. Engineering News-Record. (*Formed by the combining of* Engineering News *with* Engineering Record.)
405. Glückauf, Berg- und Hüttenmännische Zeitschrift.
406. Monthly Weather Review.
407. Jornal de Sciencias Mathematicas, Physicas e Naturales, Lisbon.
408. Journal de mathématiques pures et appliquées (Paris). (*Continues* Annales de mathématiques pures et appliquées; *present name dates from 1836.*)
409. Bayerisches Industrie- und Gewerbe-Blatt. (Kunst- und Gewerbe-Blatt, *1815–68; present name dates from 1869.*)
410. Edinburgh Philosophical Journal, 1819–26; Edinburgh New Philosophical Journal, 1826–64; Quarterly Journal of Science, 1864–70; Quarterly Journal of Science and Annals of Mining, Metallurgy, Engineering, Industrial Arts, Manufactures and Technology, 1871–79; Monthly Journal of Science and Annals of Astronomy, Biology, Geology, Industrial Arts, Manufactures and Technology, 1879–85.
411. Proceedings of the North East Coast Institute of Engineers and Shipbuilders.
412. Horseless Age. (*Merged into* Motor Age *in 1918.*)
413. Journal of the Royal Aeronautical Society. (Annual Report of the Royal Aeronautical Society, *1866–96; superseded by* Aeronautical Journal; *later* Journal of the Royal Aeronautical Society.)
414. Mitteilungen über Forschungsarbeiten auf den Gebiete des Ingenieurwesens hrsg. vom Vereine deutscher Ingenieure.
415. Journal of the Textile Institute.
416. Brennstoff-Chemie.
417. Iron and Steel Institute, Carnegie Scholarship Memoirs.
418. Pottery Gazette and Glass Trade Review.
419. Ohio Journal of Science. (*Name changed Nov., 1915, from* Ohio Naturalist.)
420. Bulletin de la société d'encouragement pour l'industrie nationale.
421. Journal of West Scotland Iron and Steel Institute.
422. American Machinist.
423. Transactions of the American Foundrymen's Association. (Journal of the American Foundrymen's Association, 1896–1904.)
424. Oesterreichische Zeitschrift für Berg- und Hüttenwesen. (*Merged into* Montanistische Rundschau.)
425. Deutsche Mechaniker-Zeitung. (Beiblatt zur Zeitschrift für Instrumentenkunde.)
426. Acta societatis scientiarum fennicae. (1839–1842, Commentationes societatis fennicae.)
427. Physikalische Berichte. (Beiblätter zu den Annalen der Physik und Chemie; Beiblätter *united with* Fortschritte der Physik *and* Halbmonatliches Literaturverzeichnis *to form* Physikalische Berichte.)
428. Repertorium für Experimental-Physik für physikalische Technik für mathematische und astronomische Instrumentenkunde. (*Before 1867 was* Repertorium für physikalische Technik für mathematische und astronomische Instrumentenkunde; *also known as* Carl's Repertorium.)
429. Memoirs of the College of Science, Kyoto Imperial University. (*Before 1914 was part of* Memoirs of the College of Science and Engineering, Kyoto Imperial University.)
430. Iron Age.
431. Revue de la société russe de métallurgie.
432. Transactions of the Institution of Mining and Metallurgy (London).
433. Annual Report of the Royal Mint, London.
434. Scientific Transactions of the Royal Dublin Society.
435. Proceedings of the Institution of British Foundrymen.
436. Reports of the Research Department, Royal Arsenal, Woolwich.
437. Japanese Journal of Physics.
438. Transactions of the American Society of Mechanical Engineers.
439. Mémoires et compte rendu des travaux de la société ingénieurs civils de France.
440. Metal Industry and the Iron Foundry (London).
441. India Rubber Journal.
442. Annals of Botany.
443. Archief voor de Rubbercultuur in Nederlandsch-Indië.
444. Verhandlungen der preussischen Akademie der Wissenschaften.
445. Zeitschrift des Vereins der deutschen Zucker-Industrie. (*Before 1898 was* Zeitschrift des Vereins für die Rübenzuckerindustrie.)
446. Zeitschrift für die Zuckerindustrie der Cechoslovakischen Republik. (*Formerly* Zeitschrift für die Zuckerindustrie in Böhmen.)
447. India Rubber World.
448. Proceedings 4th International Congress of Refrigeration.
449. Caoutchouc et gutta percha.
450. Transactions of the Institution of the Rubber Industry.
451. Memoirs of the College of Engineering, Kyoto Imperial University. (*See* No. 429.)
452. Die oesterreichische pharmazeutische Post.
453. Proceedings of the Iowa Academy of Science.
454. Procès-verbaux et resumé des communications de la société française de physique.
455. Journal of the Chemical, Metallurgical and Mining Society of South Africa.
456. Gummi-Zeitung.
457. Chemist and Druggist.
458. Linnean Society of New South Wales, Proceedings.
459. Electrical Review and Industrial Engineer. (*Formerly* Electrical Review and Western Electrician.)
460. Deutsche Zuckerindustrie, Wochenblatt für Landwirtschaft, Fabrikation und Handel.
461. Proceedings of the Royal Society of New South Wales.
462. Bulletin institut international du froid.
463. Société de physique et d'histoire naturelle de Genève. Mémoires.
464. United States Public Health Service. Hygienic Laboratory Bulletins.
465. Zeitschrift der deutschen Öl- und Fett-Industrie.
466. Repertorium der analytischen Chemie (Organ des Vereins analytischer Chemiker). (*See also* No. 92.)

467. Zeitschrift für Chemie. Leipzig.
468. Kongliga Svenska Vetenskaps-Akademiens, Handlingar.
469. Bulletin of the Institute of Physical and Chemical Research (Tokyo).
470. Memoirs of the College of Engineering, Kyushu Imperial University.
471. Army Ordnance.
472. Papier-Fabrikant.
473. Cellulosechemie.
474. Zeitschrift für komprimierte und flüssige Gase sowie die Pressluft-Industrie.
475. Bulletin institut international du froid.
476. Giornale di farmacia, chimica e di scienze affini.
477. Journal of the American Medical Association.
478. Bulletin de l'association des chimistes de sucrerie et de distillerie de France et des colonies.
479. Memoirs of the College of Science and Engineering, Kyoto Imperial University. (*Divided in 1914 into* Nos. 429 *and* 451.)
480. Chemical Trade Journal and Chemical Engineer.
481. Tschermak's mineralogische und petrographische Mitteilungen.
482. Quarterly Journal of the Indian Chemical Society.
483. American Dyestuff Reporter (including the Proceedings of the American Association of Textile Chemists and Colorists).
484. Deutsches Archiv für klinische Medizin.
485. Teknisk Tidskrift. Upplaga C. Kemi och Bergsvetenskap.
486. Münchener medizinische Wochenschrift.
487. Die deutsche pharmazeutische Zeitung.
488. Archivio di farmacologia sperimentale e scienze affini.
489. Fermentforschung.
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